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THE OHIO JOURNAL OF SCIENCE

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LONG-CONTINUED DETERMINATIVE ORTHOGENETIC SERIES.*

STUDIES IN DETERMINATE EVOLUTION, IV.

JOHN H. SCHAFFNER.

There are many evolutionary movements which continue consistently and progressively from the very beginning to the highest possible level, right through a series of the fundamental subkingdoms and often in a number of distinct lines. These determinative movements show that the evolution is not primarily dependent on any special kind of environment nor on any peculiar type of organization. All special teleological notions are immediately dissipated when one once clearly grasps the real import of such consistent progressions.

1. EVOLUTION OF THE PARASITIC INTER-RELATION OF THE TWO GENERATIONS IN THE ALTERNATION OF GENERATIONS CYCLE.

In the lowest plants with an alternation of haploid and diploid generations, all individuals carry on an independent existence. There is no parasitic inter-relation of one generation on another. Such a condition is present in the brown alga, Dictyota. But certain red algæ show the first stage of a parasitic sporophyte in that the fertilized egg or zygote is not discharged or separated from the parent plant but germinates by budding and produces a number of diploid carpospores. This developing zygote of numerous diploid cells represents the first step in a parasitic relation which becomes very prominent in the higher plants. The carpospores are discharged and each one develops an independent sporophyte. Such a condition is represented by the well-known Polysiphonia. In Batrachospermum the zygote develops into a vegetative, branching sporocarp of considerable size, the carpospores being developed at the ends of the branches.

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*Papers from the Department of Botany, The Ohio State University, No. 244.

The complete parasitism of the sporophyte is attained in the living bryophytes. The lowest stage is represented by Riccia where, after a parasitic vegetative development, the entire sporophyte except the epidermal layer is transformed by reduction divisions into spores. As one passes through the bryophytes one meets successively higher types of sporophytes, each stage representing a progression toward partial independence of the sporophyte which, however, never loses its parasitism in any phase of its life.

The decided advance is attained on the level of the lowest living pteridophytes where the parasitism of the sporophyte is restricted to the juvenile phase, the individual gradually growing into an independent individual. All of the pteridophytes, both homosporous and heterosporous have the two-phased condition of the sporophyte. Step by step the importance of the independent phase is advanced until in the heterosporous pteridophytes, the independent mature sporophyte not only nourishes itself but provides a complete supply of food in the spore both for the gametophyte and for the juvenile life of the following sporophyte which is thus nourished through the mother gametophyte on food provided by the sporophyte grandparent.

In the next stage of advancement the gametophyte becomes completely parasitic on the sporophyte, and while the following sporophyte is passing through its parasitic phase it is nourished by its mother gametophyte with food furnished directly by the grandparent sporophyte. This is a decidedly progressive improvement over the previous method of furnishing a supply of nourishment to the dependent gametophyte and its offspring.

In this state the parasitic relation between the two generations has reached its determinate limit. In the angiosperms a further complication is added in a new evolutionary movement which supplies a xeniophyte, which from one point of view is simply a further elaboration of the parasitic inter-relations of the generations. The gametophyte is enormously reduced and the embryo is surrounded by the xeniophyte which functions as nurse to the sporophyte especially during the sprouting period. This development is, however, not because of any compelling necessity, since very many angiosperms have very little endosperm and the food is stored directly in the embryonic sporophyte.

Now this whole movement constitutes a most remarkable progression which keeps a straight course through all the numerous advancing lines of higher plants, through all the diversity of environments. It continues in a progressive march until the goal is reach. If we wish to see an altruistic ending, it is plainly on the surface because this progressive movement has not only taken care of the reduced and helpless gametophyte but it has also taken the embryo sporophyte and continued it in the most advantageous condition in relation to the struggle with the environment. In these respects the highest plants have evolved in the same way as the highest animals, including mammals and birds, and some reptiles, insects, spiders, and fishes in which the most remarkable evolution in the care for the young has taken place, which care is entirely absent in the lower animals as it is in the lower plants. This long-continued evolutionary movement in the dependent relationships between the two generations is, therefore, remarkably consistently progressive, orthogenetic, perfective, and determinative. It has been carried to the limit.

A consideration of the preceding series will show how untenable are the claims that parasitism or dependence leads to degeneration or reduction. Just the opposite came about. The independent generation passed through a reduction series and at last became parasitic only after the reduction had reached an extreme degree of minuteness. The completely parasitic generation, altho it never lost its juvenile parasitism, evolved step by step attaining independence in the mature condition until we have a giant Sequoia 30 ft. in diameter, 300 ft. in height, and 3000 years of age.

2. THE SHIFTING OF THE REPRODUCTIVE PROCESS FROM THE CENTER OF THE STEM OR BUD TO THE OUTSIDE.

The Meta-thallophyta present a very interesting orthogenetic evolutionary series in respect to the shifting of the reproductive activity of the sporophyte. In Riccia and Ricciocarpus, the lowest forms, the entire center of the stem or body is involved in the production of spores. In the higher liverworts, not only is the lower part of the sporophyte sterilized but the first indication of a movement of the reproductive tissues toward the outside is in evidence by the development of sterile cells or elaters in the interior of the sporangium among the sporogenous cells. In the true mosses and horned liverworts a completely vegetative columella is differentiated, the sporogenous tissue forming a cylinder within the cortical layer. Now in the evolution from a bryophyte condition to the condition of the living vascular plants, before lateral leaf appendages appeared, the sporogenous tissue must have been developed in the outer parts of the stem just below the epidermis, and even after leaf appendages were present sporangia might still be produced from the external stem tissues or at least in the leaf axils, as in some lycopods. Apparently in such primitive vascular plants like the fossil Psilophyton the sporangia were still developed at the tips of stems as in the higher living bryophytes. But in the lines which are represented by living pteridophytes, the reproductive center was shifted entirely to the lateral appendages and sporangia are borne on the leaves from the ferns on up. The shifting of the sporogenous center from the stem axis or terminal bud to a lateral appendage was one of the main factors in the evolution of indeterminate sporophytes, although with the introduction of a branching system, either dichotomous or monopodial, indeterminateness could be attained for the sporophyte as a whole even though some buds still were destroyed through the development of terminal cauline sporangia as in Psilophyton.

The movement of the reproductive process toward the periphery of the plant does not involve the epidermal layers in most of the higher evolutionary lines. In one series, however, the leptosporangiate ferns, the movement attained the extreme limit in that the sporangia are not only produced on the stem appendages or leaves but from the very epidermal layer of cells itself. Thus the orthogenetic movement has reached the determinate limit in these plants. In the lowest forms, like Riccia, the entire system except the epidermis is involved in spore reproduction, while in the leptosporangiate ferns the epidermis alone is involved in the reproductive process all the remaining tissue systems continuing permanently in the vegetative state. The movement has progressed from one extreme to the other.

In all other higher plants, however, the eusporangiate condition is normally maintained and the epidermis does not take part in spore production. The sporogenous cell is normally a sub-epidermal cell of the first layer from which the sporocytes finally develop. The reproductive process, however, continues in its centrifugal movement with the evolution of a monopodial branching system and determinate floral axes. The first flowers of the living seed plants are terminal on the main axis, as in Cycas, Dioon, etc. The continuation of vegetative growth is then from an axillary bud beside the cone. But in plants like Macrozamia and its relatives sporophylls appear only on secondary axes, both carpellate and staminate cones being developed in the axils of foliage leaves. With a further evolution of the branching system the reproductive process is shifted out still farther so that the sporophylls appear only on tertiary, quaternary or still more extreme axes, as in Araucaria, various palms, yuccas, etc. With the introduction of vegetative and short-life evolutionary processes in the higher plants, the reproductive process may undergo a recession and may finally appear again on appendages of the primary axis. But this is a new evolutionary movement changing the former gradients and may in itself show an orthogenetic progression.

3. PROGRESSIVE RECESSION IN THE DEVELOPMENT OF THE ARCHEGONIUM.

In the liverworts and mosses the entire archegonium is differentiated from a papillar outgrowth extending above the general surface of the plant. From this position there is a consistent retrogression as one goes upwards through the higher plants until the entire structure is developed internally. This movement goes parallel with the progressive reduction of the gametophyte but is not necessarily dependent on the movement. In the Anthocerotæ, which have well-developed gametophytes, the differentiation of the entire venter with the egg and ventral canal cell takes place in the internal tissues below the general level of the surface and only the neck is differentiated from the papillar outgrowth. Here then, as in so many evolutionary movements, the process of differentiation gains on the ontogenetic development and thus the initiation of the given differentiation process takes place in successively earlier and earlier stages of the ontogeny. In this case the movement is also in agreement with the evolutionary reduction of the gametophyte but is not to be interpreted as being primarily due to this cause, since exactly similar movements take place in other morphological systems where no reduction of the individual is in evidence.

In the homosporous pteridophytes, the venter always has an internal development and the neck of the archegonium is in general much shorter than in the bryophytes. In the heterosporous pteridophytes the neck consists of but a few cells extending beyond the general surface, while in the gymnosperms there is practically no papillar outgrowth whatever, the few remaining neck cells being on a level with the general surface of the body or nearly so and range from eight down to two, except in the Gneteæ. In this highest class of gymnosperms there may be three or more tiers of cells but they do not project above the surface and are not really a true neck but a new structure, something like a tapetal layer. In the angiosperms also the archegonium or egg apparatus is reduced to the extreme limit. Either there is nothing left of the ovary except the egg and ventral canal cell (polar nucleus) or the two synergids represent the last vestige of a neck. In the lower forms there is a long row of neck canal cells and these are gradually reduced to zero, there being but one in the heterosporous ferns and none in the gymnosperms. The evolution of the archegonium thus again shows a consistent orthogenetic, progressive movement through the last five subkingdoms of plants. The general movement has not been disturbed by any of the great segregative movements, resulting in phyla and classes, which have taken place in the evolution of the Meta-thallophyta.

4. The Five-fold Parallelism of the Orthogenetic Progression in the Time of Sex Determination.

In the lower multicellular algæ the sexual states are developed only in the very last cells of the ontogeny, the male and female gametes often being sister cells. From this condition, as one ascends the evolutionary ladder of the sexual plants, the time of sex determination with a dimorphism of sexual states and structures is projected backwards step by step in the ontogeny until the extreme is reached and the sex is determined in the egg, the entire individual being then, of course, normally in a single sexual state. This orthogenetic progression is in evidence both in various series of haploid green algæ and in diploid brown algæ.

In the Meta-thallophyta a similar movement takes place in the evolution of the gametophytes of both the bryophytes and homosporous pteridophytes. The lowest stage present is the synoicous hermaphroditic condition where sex is determined in the incipient gametangia. From this condition the progression leads through to the paroicous and various degrees of the autoicous condition until in the highest forms unisexuality is attained in numerous lines. The higher plants have all attained the extreme limit, namely all the heterosporous pteridophytes, gymnosperms, and angiosperms. The movement to unsexuality has a definite limit in the spore from which the gametophyte comes. But a new evolutionary series is still possible in the shifting of the time of sex determination backward into the sporophyte itself. This condition initiates a new orthogenetic movement which travels through the ontogeny backwards until the zygote is reached completing the fourth parallel evolutionary movement in respect to time of sex determination.

In the lowest type of heterosporous sporophytes the sexual state is determined in the incipient sporangia and from this condition the time of determination progresses backward through forms with monosporangiate sori, monosporangiate sporophylls with one or the other sexual state determined in the incept of the organ, through the normal bisporangiate flower with maleness determined in the flower bud first and then femaleness, through a series of more and more extreme monecious types, until the determinate limit is reached in the normal diecious condition. The progressive series from bisporangiate flowers to dieciousness is repeated many times in the seed plants including both gymnosperms and angiosperms.

In the higher fungi a truly remarkable sexual condition is established in the evolution of an incomplete primary sexual state. In some of the highest Phycomycetæ as well as in a few of the lowest Ascomycetæ the male and female nuclei, after copulation of the cells, do not immediately fuse but sometimes there is a long delay in this process. This delay is to be attributed to an incomplete primary sexualization for the time being of the nuclei involved. In some of the lower Ascomycetæ vegetative divisions take place before the nuclei finally pass to the complete primary sexual states. These cell divisions are conjugate divisions which occur in such a way that each daughter cell normally receives a pair of the conjugate nuclei. The time of incomplete primary sex determination soon begins an evolutionary retrogression through the ontogeny of the fungus in the same general manner as has been described above for the time of secondary sexual state determinations in the gametophyte and sporophyte series. At the extreme evolutionary limit, as in some smuts and in some of the Gasteromycetæ, the determination is shifted back to the basidiospores themselves which thus copulate and the binucleate or conjugate phase is established in the mycelium at the very beginning of its development. In the extreme homothallic species the first two sister nuclei which arise from the basidiospore nucleus become sexualized with the incomplete primary sexual states and act as a pair of conjugate nuclei. Thus not only is the entire mycelium normally made up of binucleate cells but the process of external copulation at the initial point is entirely eliminated. Nothing like an external conjugation remains in the system outside of the process which takes place in the formation of clamp connections.

In respect to the time of sex determination, there are thus five distinct orthogenetic evolutions or progressions which have evolved independently in five fundamentally different plant constitutions.

1. The movement in the green algae with a simple haploid sexual cycle.
2. The movement in the brown algae with a simple diploid sexual cycle.
3. The movement in the higher fungi in the time of determination of incomplete primary sexual states.
4. The movement in the haploid gametophyte of homosporous plants with typical antithetic alternation of generations.
5. The movement in the diploid sporophyte of heterosporous plants with typical antithetic alternation of generations.

One cannot help but be impressed with this remarkable five-fold parallelism. It is a truly marvelous condition and shows conclusively that fundamental evolutionary movements are not dependent on accidents of morphological differences nor on accidents of physiological and ecological relations. The evolutionary principle lies deep down in the fundamental nature of the living substance itself.

5. ORTHOGENETIC SERIES REPRESENTING INCREASE OF DIFFERENCE OR DIVERGENCE OF CHARACTER BETWEEN SPOROPHYLL AND FOLIAGE LEAF.

In the specialization of the sporophyll, there is a remarkably uniform progression from the lowest stage where there is no apparent difference until the most extreme divergences are reached at the ends of the various phyla. Among the many series available only a few which can be easily studied will be considered. Many of the lower leptosporangiate ferns, in which the sporophylls are not on a determinate axis, show no divergence whatever from the foliage leaf while among the higher species a greater and greater degree of difference is developed. In such extreme species as *Onoclea sensibilis* there is a decided dimorphism. The same movement is seen in the carpels of the Cycadales, in passing from the low forms, like *Cycas revoluta* to species of Zamia. In the conifers, the lower groups and species, like Araucaria, have very leaf-like sporophylls while the higher groups and species, like Juniperus, have blue or reddish fleshy cones in which the carpels differ enormously from the foliage leaves. The same serial movement is repeated in the angiosperms. Some Magnolias have rather prominent foliaceous tips. These carpels are probably the most leaf-like of any in the angiosperms. When one proceeds to the highest types there is the merest vestige of a correspondence with the leaf. The divergence is extreme. Thus there is plainly a continuous, progressive movement in the complexity of reactions in the leaf, proceeding from a reaction that shows no difference whatever between sporophyll and foliage leaf except for the presence of sporangia, to the condition in which the differentiation reactions are so extreme that practically all correspondence is obliterated. Again these movements show no relation to peculiarity of morphological or physiological conditions nor to any peculiarity of environment. The movements simply plough their way upward from the bottom to the top.

6. ORTHOGENETIC EVOLUTION OF DETERMINATENESS IN THE FLORAL AXIS.

The lowest living pteridophytes have only indeterminate axes, the bud continuing vegetative growth after the production of sporophylls. Flowers, or determinate reproductive shoots, are evolved at various levels in the several phyla. In the Lepidophyta and Calamophyta, flowers appear in the homosporous level. In the fern series no flowers apparently evolved in either the homosporous or heterosporous levels until the seed condition was established. All the living angiosperms and all the living gymnosperms have flowers except the carpellate plants of Cycas and the single species of Ginkgo, including both staminate and carpellate plants. We see then that the flower evolved independently in several lines and that some groups attained a high level without acquiring the determinate potentiality. The evolution is dependent neither on a definite stage of advancement nor on any particular morphological or physiological acquirement impelling to its appearance. Nevertheless, in nearly all lines, the flower does appear before the end of the series is reached. The first appearance of the determinate property, on which floral development depends, is marked by a rather imperfect mode of action as well as by decided slowness of action in bringing about the stopping of growth. Thus lower flowers often proliferate, namely, continue to grow later as a vegetative shoot, as can be seen especially in various species of Lycopodium, Equisetum, Araucaria, Larix, and Rosa. Because of extreme fluctuation also of the time of determination the number of sporophylls varies greatly. From this condition the evolution of a greater definiteness and greater promptness of determination soon becomes evident as one ascends the ladder of general advancement. Thus the cones of the lower species of Equisetum fluctuate more widely than the more advanced species. In Selaginella, the lower species, like *S. rupestris* terminate the growth of the floral axis very tardily, the bud continuing to produce sporophylls for a very long period, while species belonging to the higher groups, like *S. kraussiana*, stop growth very promptly. In every flower-producing phylum, the same movement is clearly in evidence. In Cycads the lower species have cones with very large numbers of sporophylls while in the highest the numbers are much smaller. In the Strobilophyta the evolution of the flower passes to a very extreme limit of promptness in cessation of growth. In some araucarians, as in *Araucaria brasiliensis*, the staminate cone has about 1000 stamens. As one passes up the series to the more highly evolved types the number is reduced step by step until the limit is reached. *Araucaria cookii* has about 400 stamens on the cone, *Pinus strobus* about 200, *Podocarpus sp.* about 70, *Taxus canadensis* about 7, *Ephedra trifurca* 5, *Gnetum latifolium* 2, *Gnetum gnemonoides* 1. It is impossible for the determinate movement to proceed farther unless epigyny were introduced and this did not occur in the gymnosperms.

In the angiosperms exactly similar movements occur in various phyletic lines. Some of the lower monocotyls have more than 1500 sporophylls in a single flower and the fluctuation is very great. Among the various lines which attain the limit with a single stamen or a single unilocular ovulary with 3, 2, or 1 stigmas, either with the hypogynous or epigynous condition, the following are characteristic. In the hypogynous Helobiæ, Naias has one stamen; in the eipgynous series Vallisneria has two, or one divided into two halves; in the Spadicifloræ some species have single stamens; among the grasses, some species of Andropogon have one stamen; in the epigynous Scitaminales Canna and other genera have half a functional stamen left; in all the higher orchids there is a single stamen.

The same conditions evolve many times in the dicotyls, although more commonly the limit is two stamens or rarely two half stamens as in Salvia. The most extreme determinateness appears in the higher types of epigyny, where, although the number of sporophylls may not necessarily be reduced to the extreme limit, the center of the flower bud or flower axis actually stops growing before any floral organs have developed. This is possible because the floral organs are lateral appendages and can be developed from the cortical tissue around the center even though the growth of the center has ceased. Thus the culmination in the main evolutionary movement of the flower has been attained. If the bud stops growing before the floral parts appear the possible limit has certainly been reached. No further evolution in the given direction is possible in passing from complete indeterminateness to the extreme of determinateness. This acquirement, through progressive degrees of greater and greater promptness in the process of determination, of the floral axis brings us face to face with the serious aspects of the fundamental nature of evolution. It brings into clear view the reality of the proposition heretofore made that evolution is perfective and essentially determinative. The entire evolutionary history of the flower in its main characteristics shows a universal, progressive orthogenetic, movement which makes its way through the conditions of environment to the very limit. The limit is essentially the same whether, through other evolutionary movements, the plant has in the meantime progressed under the water, or into the desert. When one studies the taxonomic series, one is profoundly impressed with the orderly forward movements of all fundamental evolutions. The persistent reduction of the floral axis is especially impressive since it can be observed in so many different and independent phyletic lines.

7. EVOLUTION OF THE LATERAL BUD SYSTEM OF WOODY PLANTS.

The sporophytes of the liverworts and mosses have a single terminal growing bud. When this bud is destroyed through sporogenesis, the individual begins to die. In the Pteridophyta two types of branching systems are evolved, the dichotomous or bud-twinning system and the monopodial or lateral-bud system In the main series, many ferns still have practically nothing except the single growing apex. Among the rhizome ferns, sporadic lateral buds and finally branches are usually produced. Now this origin of lateral axillary buds in the main series of higher plants forms another orthogenetic, accumulative movement which can be traced upwards with a fairly constant progression Among some of the cycads, only a few sporadic branches are produced while in the more highly evolved stem of Ginkgo, along with the addition of an internodal potentiality, a double system is present. Part of the time the more primitive heredity is in operation in a bud when it develops a dwarf branch on which normally no axillary buds are organized, and part of the time the buds develop with the new internodal potentiality in activity when a functional lateral bud is organized in each leaf axil.

The evolution of lateral buds can be followed to good advantage in the conifers. In Araucaria the leaf axils of the main stem do not develop functional buds except at rhythmical intervals. After a zone of stem is developed without buds, suddenly a ring of functional buds appears which immediately produces a whorl or zone of lateral branches. These branches also show sporadic development of buds in their leaf axils. Thus the main stem develops comparatively few functional axillary buds. Passing upward toward the higher conifers, as in Abies and Picea, the rhythmical development of zones of axillary buds continues; but sporadically many axils develop functional buds and branches between the successive, rhythmically developed bud zones. In the lower pines, the succession of whorls of branches is much the same as in the araucarians, spruces, and firs, but all the leaf axils in between also develop functional buds which give rise to small, determinate dwarf branches. The same development of axillary buds and dwarf branches takes place on all the long branches. Thus in pine every leaf axil on the main shoot and long branches produces functional buds except the winter bud scales. Presumably the winter or resting bud was evolved before the general bud-development-potentiality was introduced. The dwarf branches also produce no functional buds, thus recapitulating the more primitive condition as in Ginkgo. Now in the higher species of Pinus many of the buds between the successively developed whorls of main branches also grow out into main branches and so these higher types become much less symmetrical in form than the lower types. On the various advancing levels of other series, the movement is also toward the production of more and more functional buds, and commonly more branches, until the limit is reached with a functional bud in each leaf axil. Going up to the typical woody dicotyls, one finds a functional bud normally in every leaf axil produced on the entire tree excepting the axils of the scale leaves of the resting bud. The movement is thus carried out rather consistently and the progression is from sporophytes with a single terminal growing bud to more and more numerous axillary buds until the extreme is reached with every vegetative axil developing a bud. This movement when carried out without the interference of other potentialities which might inhibit the growth of buds into branches results then in the evolution of a more and more complex branching system, from no branches whatever to such species among the conifers as *Juniperus virginiana* and *J. barbadensis*, or among the dicotyls as *Ulmus americana* and *Fagus grandifolia*, where the branch and twig system attains enormous complexity. Of course, evolutionary movements may and do arise in the higher series which run counter to this developmental capacity and thus simplifications may appear in the plant body. These simplifications, however, do not indicate simplification of the fundamental hereditary potentiality of the cell but rather, in practically all cases, the simplification and reduction of structures are brought about by actual advancement in complexity of the hereditary potentiality or reaction system. One such interference is the movement toward shortening of the life of the individual down to an annual. In such cases then an annual individual, on rejuvenation and prolongation of growth activity, may develop a much more complicated branching system than usual.

8. EVOLUTION OF THE POLLEN-TUBE.

The pollen tube represents a new development brought in with the evolution of the seed habit in the higher plants. The pollen-tube, morphologically, simply represents the bulging out of the top cell of the antheridial wall in preparation for the discharge of the male cells. Since the general trend of the heterosporous pteridophytes is toward the evolution of parasitic gametophytes, it is easy to see how the tip cell of the vestigial antheridium could be involved in the acquisition of a parasitic habit. From fossil evidence it appears that in the first stages of seed evolution, the ovule or megasporangium broke open entirely, while the female gametophyte was growing as a parasite within, in much the same way as in the more primitive condition when the megaspores were discharged. The pollen-grains that happened to lodge in this break would thus come near to or in contact with the surface of the female gametophye and the sperms would be discharged into the open and finally find their way down through the exposed necks of the archegonia. As the parasitic habit was evolving, the pollen-tube partook of the parasitic nature. Now when the ovule progressed in accordance with its own evolutionary trend and the ovule finally failed to develop a complete break in the nucellus, the pollen-tube, through its parasitic property, was able to penetrate the small amount of tissue, being guided, no doubt, by a more or less definite sex-reaction, initiated in the female gametophyte below. Thus on penetrating through the tissue below the pollen chamber, the sperms were discharged into the depression into which the necks of the archegonia opened. This condition is present in our living cycads, as in *Cycas revoluta*. Now an orthogenetic movement is on the way, and as one passes up the various phyletic lines of seed plants, a more and more efficient pollen-tube is encountered until the parasitic growth attained is truly marvelous, both as to extent and rapidity of development. Such a complicated evolution as the origin and development of the pollen-tube, along with all the other remarkable advances in the evolution of the seed habit, is understandable on an orthogenetic progressive principle, while on any teleological basis of utility and advantage to the individual, the whole subject takes on a fantastic aspect.

In the highest species of the living Cycadophyta, *Ginkgo biloba*, the pollen-tube development is of the same general nature as in the cycads. In all plants above this level, the pollentube always penetrates to some distance into the female gametophyte. In the conifers there is no pollen chamber, the last vestige of a dehiscing megasporangium being obliterated, so the parasitic development of the pollen-tube begins on the surface of the nucellus and grows down until it reaches the venter of the archegonium into which the nonmotile sperms are discharged. The parasitic nature of the pollen-tube has increased very greatly in the Angiosperms so that a very long development precedes the growth through the nucellus. The tube grows through the stigma and style, enters the micropyle, and, after penetrating the female gametophyte, discharges the two sperms. One of the most extreme developments is in Indian Corn, *Zea mays*, where the pollen-tube grows down the very great length of the silk in about 32 hours. The highest expression of the parasitic ability of the pollen-tube is probably met in such plants as various species of the Amentiferæ where the efficiency of the tube is so great that it is able to penetrate directly through the side of the ovule or through the chalazal region, as in Casuarina, Ulmus, etc. In this respect as in many others, the Amentiferæ represent a high stage of evolution and not a primitive condition as is implied in their common placement at the base of the taxonomic dicotyl series. The irrational taxonomy still commonly in vogue is one of the chief hindrances in the understanding of correct evolutionary movements. Some of the older arrangements would require the complete re-creation of the species or group before any evolution could even be postulated aside from the hap-hazard or anarchistic kind, for which witches and fairies alone could be responsible. In the evolution of the pollen-tube we have, therefore, another important, orthogenetic progressive series which keeps a definite forward march along with other progressive movements that have taken place in the seed plants.

9. ORTHOGENETIC ADVANCEMENT IN THE GENERAL COMPLEXITY OF THE LIFE OF THE SPOROPHYTE.

Not only are there definite progressive movements in the various morphological systems of the individual but the life of the individual taken as a whole shows the same characteristic progression. In Riccia, the lowest type of liverworts, the entire life of the sporophyte is spent within the confines of the archegonium venter. In Marchantia and other liverworts there is at first a period of internal development and then the outer end of the individual breaks through the venter and development continues to maturity with existence in the external world. In the higher mosses there is not only an external existence but a functioning phase of various important physiological processes, like photosynthesis and transpiration. In Anthoceros a long-continued growth activity is added, which is continued even after spore maturity has begun. In the homosporous pteridophytes the important indeterminate phase is added to the complexity of the life history. In the seed plants there is not only a double-phased existence, but a definite resting period with subsequent sprouting or re-awakening is added to the complexity of the life of the sporophyte. Thus it is evident that these general conditions of life also represent progressive accumulations, each potentiality or set of potentialities being added to the system thus far evolved. The evolutionary process is a duplicate in a general way of the ontogenetic process through which the individual is developed, with an important difference, however. For while the ontogeny is a progressive awakening to activity of the potentialities present in the cell, the phylogenetic or evolutionary process consists of the definite addition of new potentialities through which the orthogenetic series is unfolded. The higher sporophytes, therefore, have all of the processes and accidents of life which all the lower and intermediate forms possess collectively, namely, (1) internal development, (2) external development, (3) independent functioning, (4) functioning after reproduction, (5) two-phased life, (6) resting period between phases, and (7) re-awakening after rest, or sprouting.

THE SCIOTO MARSHES OF OHIO: A STUDY IN THE GEOGRAPHY OF ONION CULTURE.[1]

CARL DUDLEY VARVEL,
Ohio State University.

THE AREA AS A UNIT.

The Scioto Marsh, a bog soil province in the western part of Hardin County, is the largest of several such areas in the glaciated region of Ohio. The term "Marsh" is no longer used here in the technical sense, but is a "carry over" from the days before the area was drained. It extends over 16,000 acres[2] and is believed to be one of the largest continuous onion producing areas in North America. Here the growing onion characterizes the summer landscape. The subject of its culture is foremost in local conversation. Onion cultivation leads successively to a condition of distinct wealth or relative poverty. It motivates an interstate migration of interesting laborers and furnishes the raison d'etre of three settlements within the local region.

The greatest agricultural interest of most of the landowners is the onion. On an average about 3,500 acres of onions are harvested. In recent years the acreage has diminished largely as a result of several years of unfavorable climatic conditions which minimized the merchantable yield per acre. In 1915, an exceptional year, over 5,500 acres were harvested.

In approaching the region from all directions one sees distinctly the terminal moraines and other glacial deposits. (Fig. 1.) The deposits at the north are part of the watershed between the Ohio River system and the Lake Erie drainage basin. The drumlins and kames at the west and south enclose the marsh and divide the waters of the Scioto Valley from those of the Miami Valley. The gravel from these glacial deposits has been used in making the numerous roads within the marsh and as well in making the deep "fills" in the construction of the Erie Railroad across parts of the former bog.

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[1] The writer acknowledges much helpful advice given by Dr. Eugene Van Cleef and other colleagues in the preparation of this study.

[2] Dachnowski, Alfred. Peat Deposits; Geological Survey of Ohio, Bulletin 16 (1912), p. 72.

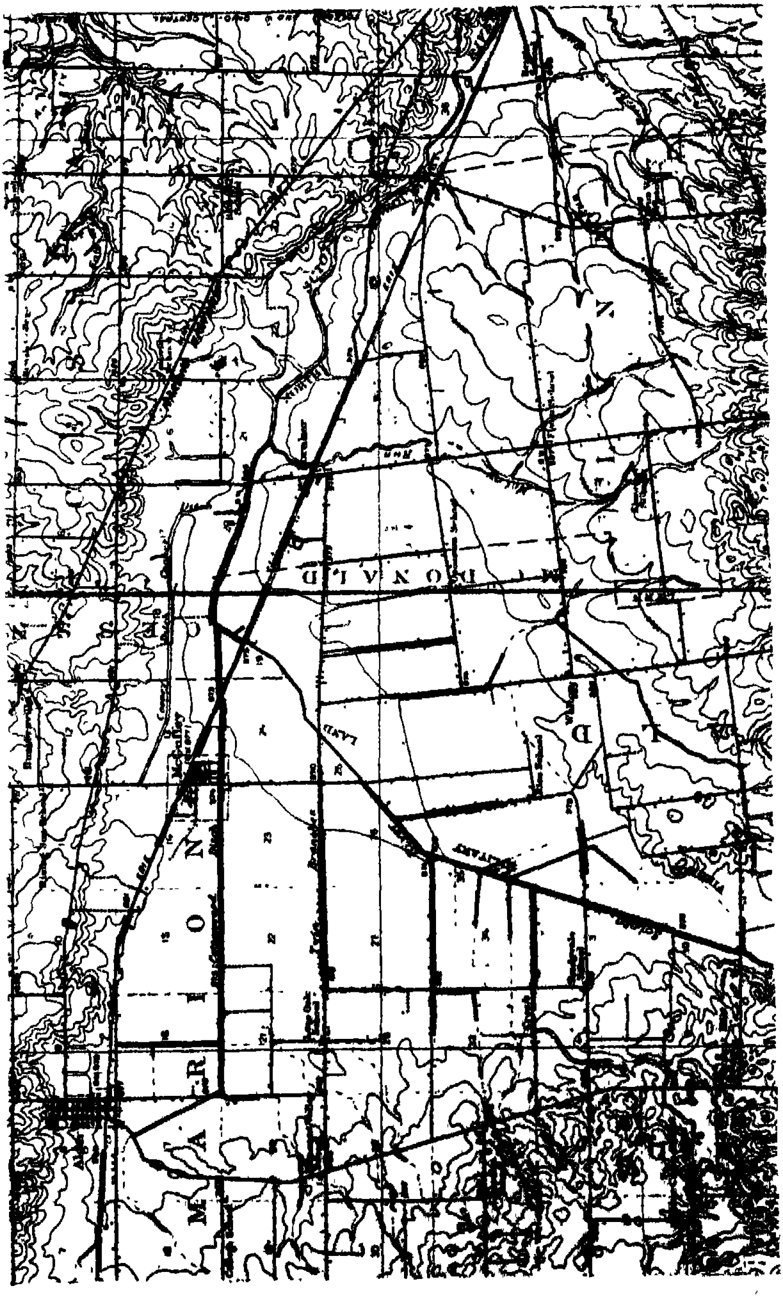

FIG. 1. Topographic map of Western Hardin County, including the area of the Scioto Marsh. (Scale: 1 inch = 1 mile. Contour interval 10 feet.)

LOCATION AND ACCESSIBILITY.

The area is crossed by the main line of the Erie Railroad and is less than ten miles away from the main line of the Pennsylvania Railroad, both roads connecting Chicago and New York City. It benefits by proximity to these lines of transport, for by a very short haul the agricultural crops can readily be exported to the great centers of food consumption. Paved roads through the middle of the marsh join the east-west Harding Highway, one of the main federal highways in North Central Ohio. Gravel roads built upon the banks of the dredged streams provide access to every farm and facilitate the speedy movement of the crops to the trunk highways and railways.

THE SOIL AND DRAINAGE.

The Scioto Marsh is the drained area of a former glacial lake.[3] For approximately 10,000 years the basin was in the process of being filled by the accumulation of vegetation.[4] It was deposited over layers of shell marl and clay which were washed into the former lake by the freshet streams which flowed into it. This action has produced a layer of peat material from two to ten feet in depth. The peat material, which coincides with the 980 foot contour line, provides a deep soil of amazing fertility. This region ranks among the best farming land in Ohio.

The floor of the basin is perfectly flat and unbroken in appearance save by the low dikes along the dredged water-courses. Rows of willow trees planted to serve as windbreaks cut the agricultural land into many plots, but these trees only accentuate the flatness of the great lacustrine plain. (Figs. 2, 3.)

Artificial drainage of the bog marsh was begun in 1859, but little was accomplished. It was resumed in 1883 and virtually completed in 1887. The Scioto River, which enters the Marsh at the southwest was, before drainage, said to be "lost" in the bog. One of the pioneers said that there was no river channel and that the present arbitrary course of the river

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[3] Winchell, N. H. Geological Survey of Ohio; Vol. II, p. 353.

[4] Dachnowski. *op. cit.*, p. 73. "It is believed that the Indians by burning the grasses and sedges for the purpose of driving game from their hiding places delayed the filling of the basin."

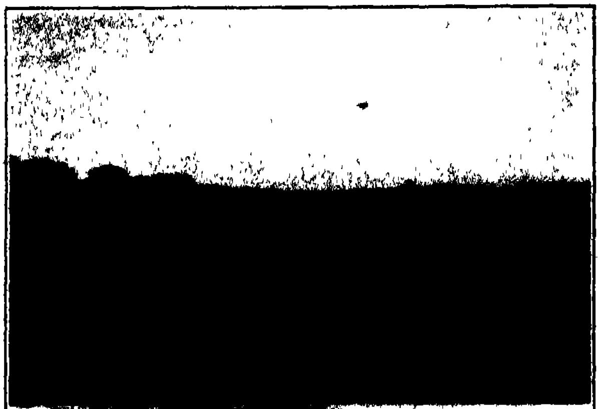

Fig. 2. The Scioto Marsh area includes 16,000 acres of distinctly level land.

Fig. 3. Willow trees are planted to break the force of the winds which in early spring cause severe losses by blowing away the loose "muck" and seeds before rooting has started.

Fig. 4. Each "weeder" cleans two rows as he crawls along protected against the hot sun by his wide-brimmed straw hat.

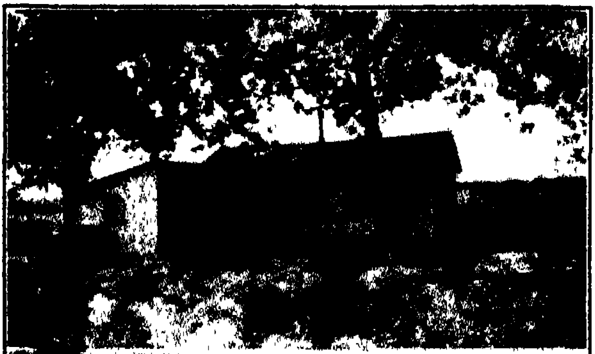

Fig. 5. A characteristic "workers" house provided for the migratory laborers from Kentucky. Most of these are located upon the dikes of drainage ditches.

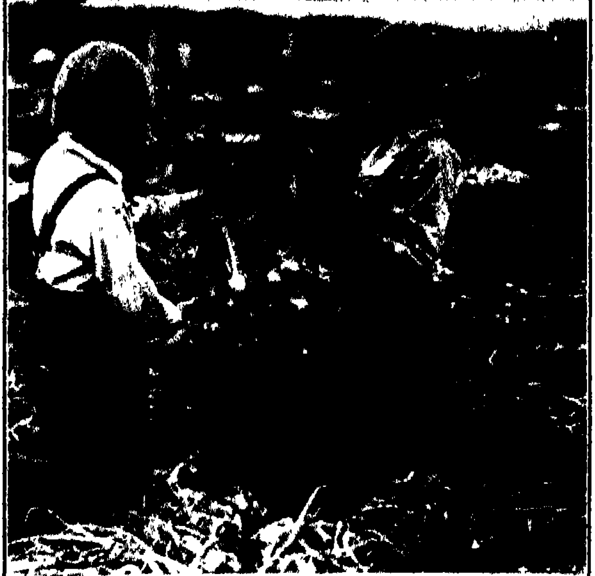

Fig. 6. The method of filling the crates is fairly simple. Sheep-shears are used to cut the tops, which are discarded and left to fertilize the soil.

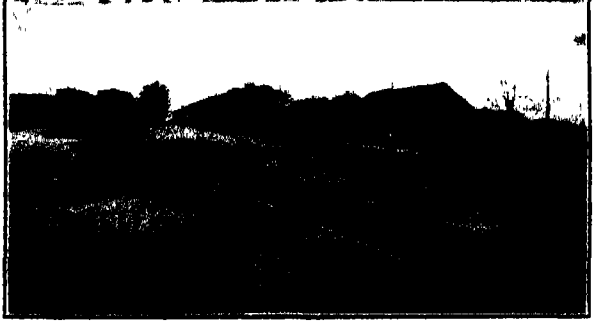

Fig. 7. Permanent storages (right) located near the double tracked Erie Railroad facilitate the speedy shipment of the crop to the chief centers of consumption.

is the result of the surveyor's lines. The present straight course of the river (Fig. 1) seems to lend support to this statement. Drainage lowered the natural outlet of the Marsh at the eastern apex of the lowland triangle. The main channel of the Scioto River was joined by many lateral ditches. In these ditches the sluggish speed of the water causes considerable silting. Almost constant dredging is necessary to keep them functioning properly.

Drainage has transformed the former bog into an agricultural province which is today completely cultivated. Excessive drainage has transformed the surface peat in several localities into a fine-grained material which is readily eroded by the wind. Dust storms in early spring are not an uncommon occurrence.

CLIMATE.

The distribution of temperature and rainfall during the growing season, May to September, is ideally suited to the onion crop. The period between the last killing frost, dating about May 5, and the first killing frost, averaging October 7, gives a growing season of about 154 days.[5] During this period the range of the average monthly temperatures lies between 60° F., for May, and 73° F., for July.

The rainfall during this season averages somewhat over half of the normal annual rainfall of 36 inches. (Chart 1.) September, the driest month of the growing season, is favorable for the harvesting and field storage of crops. The spring season usually is humid and windy. However, in some years an early drought occurs and then the wind is free to blow away the fine dried-out peat as mentioned before.[6]

Very high and very low temperatures are frequently recorded but these rarely affect the growing crop. From 1920 to 1930 the average of the annual maximum temperatures was 96.3° F. The minimum temperatures during the above decade averaged —7.6° F. The low winter temperatures are dangerous to stored onions unless the warehouses, called storages, are constructed extra well or have heating facilities.

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[5] Peattie, Roderick. Geography of Ohio, Bulletin 27 of the Ohio Geological Survey, pp. 18–20. (After W. H. Alexander, Meteorologist, United States Department of Agriculture.)

[6] In some years the onion fields must be seeded three times due to wind erosion.

CULTIVATION IN RELATION TO CERTAIN WEATHER CONDITIONS.

Abnormally humid spring weather will check the growth of the onion roots so much that the plants tend to grow on top of the ground with the general result that the bulbs are of small size, although the tops have grown very high. When a thunderstorm is followed by hot sunshine the tops are "scalded" and growth then ceases.

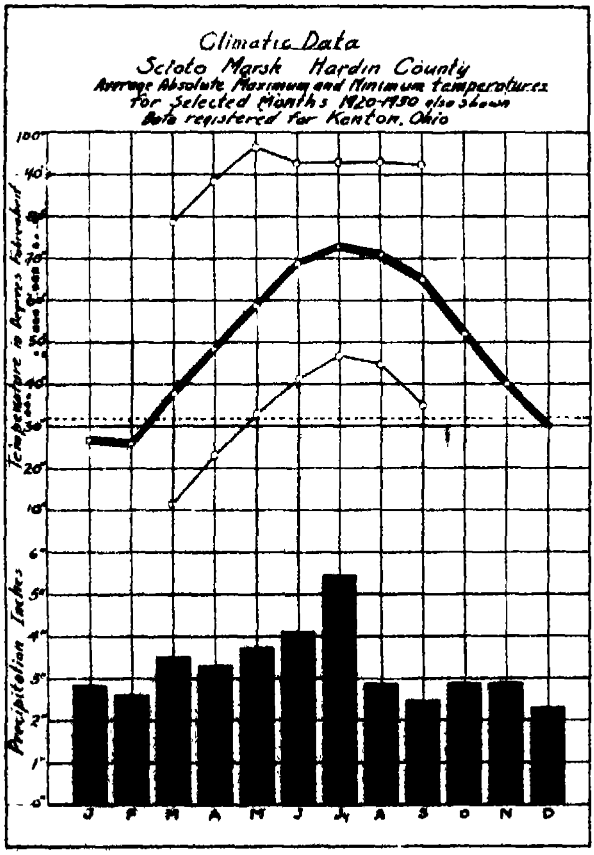

CHART 1.

A fairly dry spring seems to produce a great root length and a good plant. A series of fairly dry seasons has provided high merchantable yields while a series of wet seasons has resulted in the growth of small onions of relatively low market value.[7]

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[7] Table I, yield for 1922. Excess rainfall 10.45 inches.

While a season of slight drought is favorable for onion crops, a particularly dry summer tends to bring about a fire hazard. Peat soil is combustible.[8] In 1914 a "muck fire" damaged nearly 100 acres of excellent soil and so threatened the whole area that it was necessary to call the state militia for fire-fighting purposes.[9]

THE PEOPLE.

Three village settlements—Alger, Foraker, and McGuffey—are located within the area. They act as "service stations" and cater to the simpler wants of the people in supplying groceries, everyday clothing, and other necessities. To some degree they are important as places of amusement. They are the shipping centers for the agricultural surpluses, each of them being served direct by the Erie Railroad.

A form of trans-humance is practiced by a great number of laborers who migrate between this locality and their original homes in the "Mountain Country," mostly from Breathitt, Perry and Letcher and adjacent counties in southeastern Kentucky. It is not definitely known why these people were attracted to this area, but it is reported that they were induced to come by some of the growers who saw the need of a great many seasonal laborers who could be depended upon to work conscientiously (for relatively low wages).[10] It is estimated that on an average somewhat over 400 families make the annual migration. They travel for the most part in their own automobiles.

The clannish customs and suspicious ways prevailing among these people are rather striking in contrast to life of the local land owners and permanently resident farmers. These laborers are sociable among themselves, but non-communicative to the casual traveler; however, after proper introductions are made they are ready conversationalists. They tend to retain and use curious words which are associated with the Elizabethan Age in England. The writer noted such common expressions as "yit" for yet, "git" for get, "clum" for climbed, "fur" for for, "holp" for help. They refer to their luggage as a "budget." When one hears that the onion "crap" was "mightily plenteous" he is carried back to Elizabethan England.

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[8] An analysis of soil taken in the middle of the area by Dachnowski (Footnote 2) showed that dry peat contains volatile matter of 59%, fixed carbon 27%, sulphur 1.2%, nitrogen 3.4%. Dachnowski, *op. cit.*, p. 73.

[9] Information given to the writer by Judge W. W. Bowers, Secretary of The National Onion Grower's Association, Kenton, Ohio.

[10] Conversation with Mr. Val McGuffey, a pioneer resident of McGuffey, Ohio. He reported also that Negro labor was used formerly for a short time, but that it was unsuccessful presumably due to the social friction which occurred.

These folk are honest, but not particularly thrifty. Some who elect to remain in the area during the winter in certain years are often dependent upon official charity even when their earnings have been considerable.

Meagerly furnished houses of one or two rooms (Fig. 5) are provided generally without cost to these migratory families. It seems that such houses are no better or worse than the cabins in which they live in the Kentucky Mountains.[11]

PRODUCTION MECHANICS

The seeding of the onion lands begins normally about the first of May. Seeds are planted in rows about twelve to fourteen inches apart. Both domestic and foreign seeds are used; a few of the growers produce their own seed. Virtually no stirring of the soil is necessary in cultivation, but the problem of weed eradication is a large one While on some farms the hand wheel hoe has been adopted as the means for keeping the crop clean, generally it is found that hand-weeding is the most practicable and profitable. Men, women, and children, on hands and knees, and wearing broad-brimmed straw hats (Fig. 4) crawl back and forth along the rows (each person taking two rows or more) pulling the weeds as they go. They drop them in place where they soon wither under the hot rays of the summer sun. Weeding must be done continuously owing to the fact that the weeds thrive as well in the rich soil as the onion itself. Although the weeds do not seed themselves, copious quantities of seeds are blown in from the surrounding lands to aggravate the problem annually. The great labor expense for weeding is believed by many of the growers to be a large cause for the small profits in the onion industry within this area.

Harvesting begins when the onion tops begin to wither. This is usually in mid or late August and very rarely does it begin later than September 1. Some growers stop the growth of the onion by lightly rolling the tops to break them, thus gaining a slight time advantage in early marketing. The onions are pulled by hand. On most of the farms it is the practice to throw several rows of onions together for a few days drying before the topping begins.

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[11] Davis, D. H. Journal of Geography, Vol. XXIX. (1930), pp. 90–91. (Photographs of Mountain Cabins in southeastern Kentucky.)

The "toppers" hold a large handful of onions over a crate (Fig. 6) and snip the tops with sheep shears. The crates when filled are stacked usually four crates high for further drying and covered with tar paper to await the buyer.

The grading and cleaning of the onions is done in a long inclined slatted rack into which they are dumped crate by crate. They are mulled over by hand to push the small onions through the slats and to loosen the excess onion skins which with the clinging soil falls or blows away. This is done in the fields and in field storages. Onions larger than one and three-eighths inches in diameter are classified as U. S. No. 1, known to the trade as "boilers;" those smaller are called "picklers." For shipping they are packed in bags of 100 pounds, stamped with the proper grades for the market.

MARKETING THE CROP.

Nearly all of the average crop of 1,000,000 bushels (Table I) is handled by brokers, called "buyers," many of whom are growers as well. In a poor season of low production, buying may begin even before harvest, but usually it begins as harvesting is finished. The brokers have wide contacts in the large consuming centers in all parts of the United States and Canada, while the tenant or "share-farmers" have none and of necessity pass to the buyers the job of placing the crop on the market. Competition is frequently keen among the buyers, especially for certain kinds and classes of onions. Personal honesty ranks high and virtually all of the sales contracts are made orally. The writer witnessed one sale of 20,000 bushels which was consummated by a single offer and acceptance which took less than a minute after an inspection of three crates of onions had been made.

Onions are perishable and little if any of the crop may be successfully or profitably stored after April 1, even in the best storages. (Fig. 7.) Few of the growers care to attempt long storage in common onion sheds on the farms for the winters with freezing weather bring disastrous results to a commodity with such a high water content.

The distribution of the crop is wide. Coal mining regions and steel making centers are especially good markets and have been found to provide a greater per capita consumption than other centers. Southern markets seem to demand Ohio onions, and a great many cars are sent to Louisville, Atlanta, Birmingham and Memphis. New York City buys 18 cars of onions per day. Chicago consumes nearly four cars per day.[13] The total average annual shipment to all markets is 1,800 cars.

TABLE I.

PRODUCTION OF ONIONS IN HARDIN COUNTY, OHIO, 1920–1930.
(Data from U. S. Department of Agriculture.)

YEAR	BUSHELS	ACREAGE HARVESTED	BUSHELS PER ACRE
1920	1,158,000	f	340 g
1921	617,000	f	225 g
1922	1,550,000 c	f	400 g
1923	780,000	f	253 g
1924	1,504,000	4,050	350
1925	255,000 a	1,200	298
1926	582,000	2,500	247
1927	1,500,000	4,400	330
1928	530,000	3,500	147 b
1929	930,000	4,300	260
1930	1,056,700 e	3,800 d	278
Average	951,150	3,583	284

a. Severe drought. Precipitation April–September, 9.87 inches. (Normal, 17.72 inches.)
b. Severe maggot infestation.
c. Copious rainfall. Precipitation April–August, 28.17. Normal, 17.72; excess, 10.45.
d. Decreased acreage probably due to low prices of 1929.
e. Preliminary estimates.
f. Data not available.
g. Data by Mr. H. C. R. Stewart, Crop Reporting Service, United States Department of Agriculture.

RELATION TO OTHER GROWING AREAS.

Ohio onions must compete with those grown in many other states, as well as with importations from abroad. Smaller onion producing areas are located in many parts of northern Indiana and Illinois, southern Wisconsin and Michigan, in many parts of western New York, here and there in New

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[13] Conversation with Hon. J. B. Stambaugh, Ada, Ohio, former president of the National Onion Grower's Association.

England. There are scattered fields in southeastern Texas and still other widely separated fields. (Fig. 8.)

Twenty-five foreign nations ship onions in varying amounts to the United States. Spanish onions come in at the same time the Scioto crop is being harvested. England, Germany, Denmark, Canada, and even far-away Australia are general competitors.

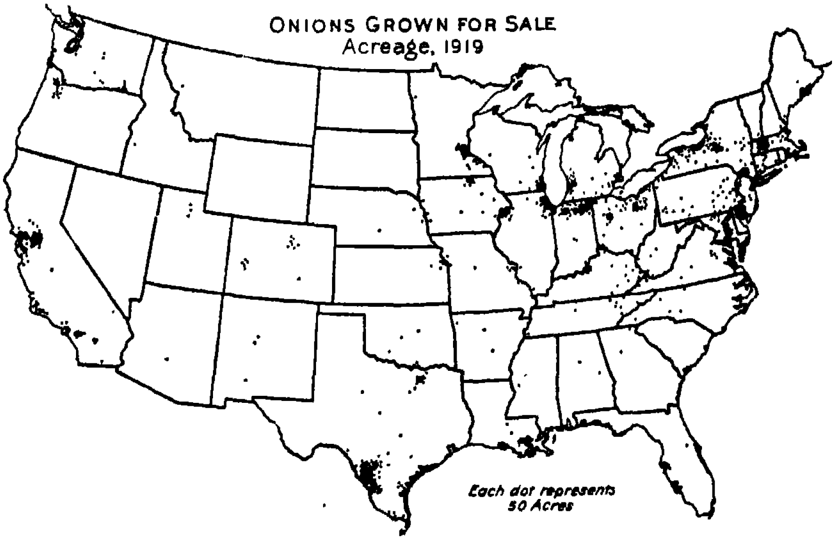

Fig. 8. Distribution of onions grown for sale in the United States. (U. S. D. A.)

The National Onion Grower's Association has succeeded in securing an increase in the tariff rate from 1 cent to 1½ cents per pound, an increase of 50%, which became effective on January 1, 1929. This was raised by the Smoot-Hawley Bill of 1930 to 2½ cents per pound. This is expected to give some advantage to domestic producers everywhere. The industry is one of large proportions and according to many of the Scioto Marsh growers has been an industry of very small profits for the past four years. However, should foreign importations be sharply reduced under the new tariff act of 1930, as is confidently expected, the acreage on the Scioto Marsh should undoubtedly rise to former high levels.

THE NATIVE IRIS OF OHIO AND BORDERING TERRITORY.*

A. E. WALLER.

Sufficient progress in the study of the native American species of the genus Iris as locally represented has been made during the past five years to warrant the publication at this time of a list with a key and distribution maps. Before 1926 the State Herbarium had only two species listed, the northern blue flag, *Iris versicolor*, L. and the crested dwarf Iris, *Iris cristata* Ait. The leafy blue flag, *Iris foliosa*, Mack and Bush, although known to have been collected in the state, was not represented in the Herbarium. The intervening years since 1926 have witnessed an awakening enthusiasm for native iris, occasioned in part by collectors of garden iris, but chiefly resulting from the availability of certain valuable botanical publications. These Iris papers have shown conclusively that in spite of its showiness and the natural attractiveness of its flowers, the genus has been decidedly neglected by the botanists. A conspectus of the genus, which has about 170 species, goes back to Sir Michael Foster and Mr. W. R. Dykes. The former's great interest in collecting and classifying, after having grown the plants, bore fruit in the monograph of the genus by Dykes (2) published in 1913. The monograph, probably not circulated much beyond the greater libraries was happily followed by a Handbook (3) in 1924 by the same author. The Handbook furnishes a convenient guide to anyone interested in the genus and has made it possible for the many garden enthusiasts to become acquainted with a group of most interesting plants. During the same period, Dr. John K. Small (6), (7), of the New York Botanical Garden, has added a new interest to native American iris by his collections of many fine forms in the Southeastern States from Florida to the Mississippi Valley. Also during this period, Mr. Edgar Anderson (1) of the Missouri Botanical Garden, has cleared up the confusion in nomenclature of *Iris versicolor* and has shown that what was negligently classified under that name is really a pair of distinct species with definite characters and decidedly different geographic ranges.

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*Papers from the Department of Botany, The Ohio State University, No. 268.

The purpose of this paper is to call attention to our local species. Since the political boundaries of the State bear no relation to origin or migrational history of a group of plants, it is thought best to include such native American species as we have in our closely surrounding neighboring States, attention being in each case given to the proved records of their collection from actual Ohio territory.

METHODS OF STUDY.

The collection of iris into gardens lends itself particularly well to modern taxonomic study which at present demands more than the preservation of good herbarium material. There are several reasons for herbarium specimens being unsatisfactory. The first one is that iris flowers are perishable and delicate and not easy to determine in the dried state. Iris specimens usually defy all attempts at dissection. Few herbaria have specimens with complete parts of the plants included. Seeds, capsules, rhizomes are all wanted for the diagnosis of certain species. The student of iris will do well to bear in mind that the collection of entire plants and the notes on habitats and time of bloom are important. Too much stress has been laid upon flower color, quite the most easily lost of all the characters. After a few years the Albino forms recorded in several species are completely indistinguishable from the dark forms in herbarium sheets. Consequently all collections I have made are supplemented with garden culture of doubtful species. With this method of study it has not taken long to show that the descriptions of species in our general manuals of botany are in need of revision. Few of the manuals present in concise form those differences needed for diagnosis. None have taken advantage of the convenient grouping of the species into subsections of the genus. The examination of the following paragraphs will show that the determination of a few endemic species is made easier by a study of the relation of the species to the genus as a whole.

SECTIONS, AND SMALLER GROUPS OF THE GENUS.

The iris forms commonly grown in our gardens are characterized by a prominent beard on the sepal. This has no functional significance, although inexperienced hybridizers have been known to mistake it for the stigmatic surface of the plant. It is intended at a future date to take up the naturalized species as it can be shown that a number of garden forms have escaped in Ohio and a number of species have become naturalized. The point in this connection is that we have no native bearded iris or Pogoniris in Ohio. The two main groups into which our native species fall are the *Evansia* section and the *Apogon* section of the genus.

The *Evansia* section derives its name from Thomas Evans, of India House, who first introduced a crested iris to the botanists in Great Britain. It was at one time given a separate generic name, *Evansia*, but was later put back into the genus Iris after several somewhat similar forms became known. All the Iris of this section have the median line of the sepal decorated with a white or yellow linear crest usually of three small ridges, more or less bearded or waved. The crest in the iris of this group, replaces the beard of the previously mentioned group of garden forms. Our native American species, *cristata* and *lacustris*, are the members of this section. Most of the species of the crested group are from India and China and probably most of the 8 or 9 described species have garden possibilities. Tectorum is the Chinese species most commonly introduced into our gardens.

The *Apogon* section is large and comprises nearly half the genus. However, it is so conveniently split up into a number of smaller subsections that are readily grasped by the iris growers that the whole section is scarcely ever thought of as having unity except in two main points. The iris are all without beards or crests and they are all rhizomatous. Taken together these two characters separate the Apogons from the bearded iris and the crested iris as well as the bulbous iris. If any ornamentation of the median line of the sepal exists, it takes the form of a color stripe or a minute pubescence. It is not until the fundamental divisions of the iris groups are borne in mind that a manual of local forms can be properly constructed, and be useful to some one not already acquainted with many irises.

In our American species the Apogon section is represented in Ohio by the Hexagona subsection and by a subsection that will be proposed a little further on in this paper. The Hexagona subsection derives its name from the six-angled or six-sided seed capsule. The ovulary of the Hexagona group of iris is subtended by three narrow linear troughs extending from base to apex. These troughs are bounded by prominent ridges forming ribs. The wider and more or less flat faces may also have minor ridges on them. This subsection is distinctly American and contains three species, *I. hexagona*, native in the Carolinas, not known outside of cultivation in Ohio; *I. fulva*, with a distribution center in the Mississippi Valley, but known in Ohio, and *I. foliosa*, known since 1926 to be rather widely distributed in Ohio. From the time of the proposal of the name in 1902 until 1926 the occurrence of this iris had only been definitely recorded for the State Herbarium from a colony on Middle Bass Island. There were specimens from Ohio, however, in other herbaria.

Two species of Apogons obviously closely related to one another are *Iris versicolor* L. and *Iris virginica* L. They are enough like each other that the hasty superficial methods of collecting only flowers and then finding in the herbarium a mass of collapsed material that is more an exasperation than a record, has led for many years to indiscriminate lumping of all of these under one name, versicolor. This species was thought to have been the only one of the blue flags native in Ohio. This mistake was unfortunately not realized by Dykes. Probably because of lack of critical material easily at hand, these two species were not separated in Dykes Monograph. Possibly he may have looked askance at the problems of untangling the synonymy and deferred to the current American diagnosis. It is easy on this ground to account for his remarkable summary of the range of versicolor, from Hudson Bay to the Gulf of Mexico, a range which on the Age and Area Hypothesis would readily concede to versicolor the parentage of all other iris species.

NEW SUBSECTION OF APOGONS. THE VIRGINICA SUBSECTION.

The separation of the two species has been carefully explained by Mr. Anderson, (loc. cit.) with full references to all the records of taxonomic importance.

Since Dykes did not separate the two and Anderson in making the separation used his material in such a way that the affinities are not emphasized it is here proposed to group these two into a new subsection of the genus and call it the Virginica subsection. Dykes was interested in attempting to show similarities between versicolor and Iris pseudacorus, the yellow European bog iris. Attention to this led him away from the more logical and more important consideration of the virginica-versicolor problem.

The Virginica subsection of the Apogons may be defined as comprising versicolor and virginica. It is distinct from the Hexagona group and the western group, but is related to the Gulf Coast forms.

The remaining single species of the area covered by this paper is *Iris verna* L. It does not belong to any other group of species of the Apogons. It has in the past been variously grouped, but does not have close affinities with any members of the genus. It is dwarf and has been confused with cristata, but it lacks the crest found in all Evansia irises. It is beardless, but bears on the median line of the sepals a marked pubescence of short unicellular hairs. The small flowers with erect standards and spreading falls give it somewhat the appearance of a diminutive bearded iris. However, it is not related to the dwarf bearded irises. It has not definitely been proved to be in Ohio, but is suspected and is known not far south of the Ohio River in Kentucky and West Virginia, and probably also west of Ohio, in Indiana.

Further remarks on the above plants will be postponed to examine a key to the species before discussing these individually.

KEY TO NATIVE IRIS.

- A. Dwarf plants without flower stalks, flowers borne on relatively long perianth, tubes, sepals crested.
  - B. Perianth tube narrowly funnel form, 1½ cm. to 3 cm. long, shorter than the sepals . . . . . . **I. lacustris.**
  - B. Perianth tube broadly funnel form, 4–7 cm. long, as long or longer than the sepals. . . . . **I. cristata.**
- A. Dwarf plants with short flower stalks not exceeding the perianth tube, the two together less than 7 cm. long, sepals not crested, petals somewhat arching cupped . . . . **I. verna.**
- A. Plants with flower stalks at least 8 cm. long.
  - B. Hexagonal ovularies.
    - C. Flower stalk erect, 20–50 cm. long floral segments drooping, sepals and petals coppery red **I. fulva.**
    - C. Flower stalk curved, often zigzag, sometimes procumbent, usually less than 40 cm. long, sepals and petals spreading horizontal, blue to lilac. . . . . **I. foliosa.**
  - B. Trigonal ovularies.
    - C. Flower stalk sparingly branched, ovules filling the locules, sepals usually with bright yellow blotch at base of blade, blade pubescent sepals thin textured, easily wilting, blue purple or lighter, capsule lining dull, seeds dull, corky, both rounded and D-shaped. . . . . **I. virginica.**
    - C. Flower stalk freely branching above, ovules not filling the locules, blotch; if present, green or greenish yellow, sepals relatively heavy textured, not easily wilting, reddish purple, capsule lining shiny, seed coats relatively thin, shiny, D-shaped. . . . . **I.versicolor.**

DISCUSSION OF THE SPECIES AND THEIR DISTRIBUTION.

Iris cristata Ait. Hort. Kew. 1: 70. 1789.

Plates. Dykes, pl. 25. Addisonia, pl. 320.

Description—The stem is a slender rhizome which spreads by long stolons. In a favorable location the stolons may be 6 or more in number and rather short. In the native state on eroding stream banks the stolons may be 15 cm. long without lateral buds forming. The leaves are usually less than 12 cm. at flowering time, but may be twice that length later in the season. In width they are between 1 and 3 cm. The flower stalk is short or absent and bears two or three reduced leaves at the base. The perianth tube is greatly elongated up to 10 cm., 3 angled and distinctly wider at the top. The falls (sepals) do not have any constriction separating blade and haft. The blade is broadly obovate and surmounted by three ridges. The central ridge is waved, white, tipped with orange. The lateral ridges are orange or yellowish. The central ridge becomes dotted with purple toward its apex around which is a white patch sharply outlined with lilac purple which fades to paler lilac toward the margins of the blade. The standards, (petals) are horizontal or drooping. The style branches are appressed over the falls. The stigma is oblong entire, the filaments are white or tinged, the anthers cream and the pollen white. The capsule is small, not more than 1½ cm. long. It dehisces while still green and somewhat hidden by the spathe valves. It is sharply trigonal, broader at the apex and tipped with a small point. The seeds are small, oval, and bear small gelatinous appendages which are viscid at first, but shrivel quickly on being exposed to the air.

This interesting little plant was introduced into England by Peter Collinson in 1756. It was well known to John Bartram, to Short, and other botanists of pioneering days.

Through the courtesy of the Missouri Botanical Garden I have studied their collection and find that its range exceeds that given by Small, Dykes and others.

Distribution—Iris cristata ranges through the hilly sections of Georgia and the Carolinas, across Virginia, Tennessee and Kentucky, north across Ohio to Lake Erie, across to Southern Indiana to Missouri, Arkansas and Texas. It is decidedly a plant of the Appalachian Highland rim spreading out to the Ozarks and south westward. In Ohio in post-glacial times it has migrated across the hilly eastern part of the state.

Habitat—Drained but moist and cool soils are occupied by Iris cristata. It may form a mat in association with ferns, mosses, violets and other plants of moist rock faces, but it is equally a part of drained terraces and flood plains in partial shade. As a garden plant it can be better managed in soils that have well decayed humus incorporated and kept cooled by the shade of small trees or shrubs. The stolons do not spread so far and strong clumps bearing numerous flowers are formed. Rhizomes that have flowered do not again flower. They may be discarded to make room for young stolons. Iris clumps help solve the erosion problems of partially shaded garden terraces and make ideal plants for the base of a wall wherever height is not wanted. It appears that seeds are not easy to germinate and in plants collected from vigorous patches seed production is never very heavy. The question raised by Dykes whether or not the albino form appears in the wild state or only in gardens can now be answered. Mr. Floyd Bartley, of Circleville, Ohio, brought me some white forms collected in Hocking County, in East Pike Run, where it occasionally appears among the blue flowered plants. A specimen is in the State Herbarium from this locality.

Iris lacustris Nuttall. Gen. 1:23. 1818.

Plate. Addisonia, Pl. 319.

Dykes Genus Iris, p. 106, makes *I. lacustris* a variety of *I. cristata*, but in the Handbook, p. 85, he appears to have reversed his earlier opinion and gives it as a species. The description on p. 86 is not convincing. The key in this paper gives the major points by which *I. lacustris* may be distinguished from *I. cristata*, namely, the dimensions and form of the perianth tube. In other characters there are also differences, though it must be admitted that the species are closely linked. The type specimen collected by Krebs is in the Herbarium of the Berlin Botanic Garden and has not been examined, though the Ohio State University has the material on *I. cristata*, collected by Krebs. Both are labelled "collected in Cuyahoga County." The best material I have seen of *I. lacustris* was collected and kindly sent by Dr. George E. Nichols, from Douglass Lake, in Michigan. Michigan and Ohio are the critical states for the determination of these two species as it is there that the distribution shows an overlap. In garden cultivation with me, *I. lacustris* has never succeeded well, though growing side by side with *I. cristata*. While this is not sufficient evidence, it leads me to suspect that the separation had occurred before glaciation and that *I. lacustris* was preserved in its more northern habitat on some of the unglaciated areas, while *I. cristata* was forced into a temporary retreat in the region southeast of the Moraines of Fairfield County. At least *I. lacustris*, as the name implies, has its center of distribution in the Great Lakes region.

Iris verna Linnaeus Sp. Pl ed 1, p. 39. 1753.

As mentioned previously, this dwarf iris is not at present officially recorded from Ohio. It has been reported from Adams County. However, it is thought desirable to spread our area a little to include it since it is becoming a familiar form in cultivation and it is not necessary to go far south of the Ohio River to find it in the wild state. A few years ago it was seen in a flourishing condition in the pine woods at the top of the hill at Natural Bridge, Kentucky.

Description—The stem is a slender rhizome, not bearing long stolons as in *I. cristata*. The leaves are narrowly ensiform, 10–16 cm. long at flowering time, later somewhat longer. The flowering stalk is short, the perianth tube 3–4 cm. long, rounded to trigonal. The ovulary is trigonal, the mature seed capsule with a groove on each face, is blunt at the base and tapering to the apex. The sepals are about 3 cm. long and less than 1 cm. wide, obovate cuneate. The haft is marked by a pubescent band of unicellular hairs, orange and brown, extending outward to the blade, which is uniformly purplish lilac. The falls are horizontal and the standards are arching cupped and of the same color as the blade of the falls.

The style arms do not separate at the base of the segments, but about ½ cm. higher. The styles are lighter than the blade of the falls in color. The stigma is entire. Filaments are white or tinged, longer than the anthers. The anthers are blue, the pollen creamy white. The seeds are pear-shaped, a light brown and marked with a raphe of white.

Distribution—The range of *I. verna* is in the Southern Appalachians, but it nowhere forms the matted colonies which make a conspicuous plant of *I. cristata*. It has been collected from Virginia, Kentucky, Tennessee, North Carolina, Georgia, and Alabama.

Habitat—*I. verna* requires greater drainage than *I. cristata*, but still requires somewhat cool soil in the summer. It can be successfully lifted and transplanted in early autumn in Ohio and a planting made of it five years ago to a well drained shaded slope not far from a limestone gravel walk has thrived without further attention. A planting made at the same time and put into soil that was acidulated with alum died promptly after flowering the first year. This seems to be the reverse of the experience of most gardeners. The leaves are decidedly slower to die and absciss than *I. cristata*, a fact that commends it to the attention of gardeners looking for dwarf plants with more or less evergreen foliage.

Iris fulva Ker-Gawler. 1812

Plate in Botanical Mag., 1496. Pl. in Dykes, Genus Iris, 21. Seeds, Pl. 48, Fig. 3.

No iris is more readily identified than *I. fulva*, in which the flowers are apparently lacking in the violet or purplish tones so abundant in most iris species. The color is according to Ridgeway's charts (4) between cornelian red and vinaceous rufous. (Plate 14). This is far from the conventional description as terra cotta, given both in the Genus Iris and in Dyke's Handbook and consequently found in a number of other writings. The color is far too brilliant to continue to mask under such a drab designation. The flower color and the hexagonal ovulary are sufficient to distinguish it.

Description—The rhizome is stout, becoming green if exposed and bearing the shredded leaf bases on prominent scars of the successive years growths. The flower stalk is 60 cm. or more long and bears two flowers at the apex and one or two more in the axils of short leaves. The ovulary is six-ribbed and at maturity the seed capsule may be 5 cm. long by 2 cm. broad. The sepals are oblanceolate cuneate, nearly 3 cm. broad at the widest part of the blade. The petals are emarginate and truncated. Sepals and petals are of a uniform color close to cornelian red or dark at the veins. The styles are short, about 2 cm., the stigma bears two small pointed teeth. The filaments are yellow, the anthers cream, reaching the stigma, the pollen is cream. The seeds are large, flat sided and covered with a thick coriaceous husk.

Distribution—The range of *I. fulva* is given in the Genus Iris and in the Handbook of Dykes as limited to the banks of the Mississippi near New Orleans. It is known to range from there as far north as Illinois and is reported eastward as far as Georgia. It is also known from the moister parts of Texas and Arkansas and its distribution in Western Tennessee and Kentucky is suspected.

Habitat—*I. fulva* is distinctly a swamp plant, tolerating poorly the dry conditions of most gardens. It is best planted close to a stream where it can be kept moist. The plants that I have known for the past fifteen years have been in a pasture on the farm of Mrs. Joseph Wing, near Mechanicsburg, Champaign County, Ohio, where they have spread without protection and have at times even been trampled, though never eaten by the livestock. While there is not an altogether clear record, the plants are supposed to have been brought from Clark County. I have never been able to disprove or to verify this statement, since the plants have been living in their present location without attention for such a long time. It is the habit of *I. fulva* to send out new shoots in autumn which seem perfectly able to withstand cold during the winter. The specimens in Champaign County have a number of times endured zero and lower temperatures. *I. fulva* seems fully as hardy as the related species, *I. foliosa*. It is recommended for trial in all gardens able to give it sufficient moisture.

Iris foliosa Mackenzie and Bush in Trans Acad Sci. St. Louis, 12:81, 1902.

Plate, Dykes Genus Iris, 20. Addisonia, 315.

Description—The rhizome is light brown, often with green from the leaf bases encircling it. The leaves are glaucous, 2½ cm. wide and 40–50 cm. long. In autumn when the leaves die away new shoots appear at once. These remain green, but do not grow until spring. The flower stalk is short, 15–25 cm., flexuous or distinctly zigzag so that its length is uncertain. The leaves at flowering exceed the length of the stem. The spath valves are green, 5 cm. long. The ovulary is six-angled and ribbed with six prominent ridges. The perianth tube is 1½ cm. long and ribbed. The falls are ascending spreading, a clear blue violet, the blade ovate, the haft narrowly cuneate. A large downy patch of white at the center of the falls extends in toward the haft, becoming greener toward the haft. The standards are oblanceolate of the same color as the falls. The styles are keeled, greenish along the keel. The stigma has two large lobes, the filaments are stout, about equalling the anthers. The anthers are wide, the sac being widely separated, the pollen is yellowish white and pointed. The capsule is about as wide as long, 3 cm. The ribs on the capsule meet in a rosette at the apex. The seeds are large, corky grayish buff and of irregular shapes.

Distribution—Since this iris is one for which a great number of records have been made recently, it seems desirable to give a few of these to show that this plant is not a rare one, but had merely escaped the notice of collectors. The earliest specimens were recorded as *I. hexagona* in 1897. The species *foliosa* was erected in 1902.

Iris foliosa Mack. and B.

Auglaize County—St. Mary's, A. Wetzstein, 1897, (*I. hexagona*).
Auglaize County—St. Mary's, A. Wetzstein, 1898, (*I. hexagona*).
Ottawa County—Catawba Island, Edgar Anderson, 1925.
Mercer County—Near Celina, A. E. Waller, 1926
Shelby County—Near Sidney, Joseph A. Clem, 1926
Franklin County—West of Glenmary Park, A. E. Waller, 1927
Highland County—Hillsboro, Garden escape. Katie M. Roads, 1928.
Van Wert County—Willshire, A. E. Waller, 1929.
Darke County—Ten miles north of Greenville, Hicks and McCormick, 1930.
Henry County—One and one-half miles east of Napoleon, Hicks and McCormick, 1930
Union County—One mile south of Essex, Hicks and McCormick, 1930.
Ottawa County—Middle Bass Island, C. J. Kennedy and Helen Brown, 1930.

The distribution by counties indicates clearly that this iris fits in with the distribution of Mississippi Valley plants that have migrated post-glacially northeastward along the Ohio, Wabash, and Maumee River systems across the northwestern part of Ohio. The farthest south distribution point in Ohio, Highland County, is recorded by Miss Roads as a garden escape. The farthest east record to date is Franklin County. It is further interesting to be able to record that I have seen colonies of this species in Wells County, Indiana, near the Wabash River, while collecting with Mr. E. B. Williamson, of Bluffton, Indiana. Both Mr. Williamson and Mr. Paul Cook, of Bluffton, have traced this species over to Willshire, Ohio.

Habitat—Iris foliosa is a plant of small stream terraces and succeeds well in partly shaded positions. The colonies spread vigorously and the corky seeds float to other parts of the stream. It is not easy to see how the great upstream migration could be accomplished in any but rather level country. The accompanying distribution map gives a reliable picture of the known facts. Both Sir Michael Foster and Mr. E. B. Williamson have produced hybrids of *I. foliosa* and *I. fulva* using the pollen of *I. foliosa*. These hybrids are rather widely grown in gardens, being more frequently seen than the parent species. The hybrid forms have the vigor and flower size of the pollen parent and the height of the seed parent. No second generation segregates have yet appeared in cultivation. The plants produced by the two hybridizers are readily distinguished by iris fanciers.

Iris virginica Linneaus. Sp. Plant. Ed. 1, p. 38 (1753).
Plate 36, Fig. 2, in Anderson (loc. cit.).

Description—Rhizome 2–4 cm. wide. Leaves 1–5 cm. wide, 60–80 cm. long, ensiform. Flowering stalk not much branched. Spathe valves long, 4–12 cm., sometimes becoming reduced leaves. Ovulary long, slender, 1.8–3.8 cm., walls of ovulary relatively thick, and the ovules nearly filling the locules. Sepals a blue purple with a bright yellow pubescent spot at the base of the blade. The thickness of the blade is less than the length of the hairs of the pubescences. Petals ovate spatulate, nearly as long as the sepals, of the same general color as the sepals, thin and easily wilted. The seed capsule is long and slender, the lining irregularly marked with striae, dull. The seeds are large, rounded to D-shaped, having a heavy cork wall and the seed coats are dull.

Distribution—*Iris virginica* appears all over our area. It is the common flag of our region and the earlier collections in the State Herbarium have been checked to separate *I. virginica* from the collection which was originally entirely labelled *I. versicolor*. We have herbarium sheets and sight records from most of the state. In the northwestern part of the State, *I. foliosa*, *I. virginica* and *I. versicolor* all meet.

Anderson, (loc. cit.) reports a partially sterile hybrid between *I. virginica* and *I. versicolor*. He obtained it as the result of an artificial pollination and also reports its spontaneous appearance in the areas of overlap of the two species. The Southeastern part of Ohio affords less opportunity for the occurrence of the swamp irises than the northern and western parts.

Habitat—*Iris virginica* is a plant of stream borders and marshy ground. It does not endure shade as well as *I. foliosa*, but in the open makes the most vigorous colonies of any of our iris species. It is increasing in moist pastures over the state as the livestock will not eat it except in the absence of all other herbage. It makes an excellent plant for water gardens, where a fine effect of vigorous foliage is wanted, and should have *I. pseudacorus*, the yellow swamp iris of Europe, as its garden associate. It is in my estimation a finer plant for garden effects than *I. versicolor*. Since its identity has not been clear it is uncertain whether all the garden forms that have been separated are from *versicolor* or *virginica*.

Iris versicolor L. Sp. plant ed., 1, p. 39. 1753.

Plates. Curtis, Bot. Mag. 1: Pl. 21, 1790. Meehan, Native Flowers and Ferns 1: Pl. 36, 1878. Small in Addisonia 9: 55, Pl. 316, 1924.

Description—Rhizome 1–2.5 cm. wide. Flower stalk freely branching above. Spathe valves 3–4.5 cm., never becoming leafy (see preceding species). Ovulary 0.8–2.0 cm. long in flower. Walls of the ovulary thin, ovules not filling the locules. Sepals a reddish violet, blade often without a conspicuous spot at the base. If the spot is present, the color is a greenish yellow to green. The pubescence of the base of the blade is short and inconspicuous. The petals are lanceolate, shorter than the sepals, and of firm texture, not readily wilting. The capsule is not usually as long as in *I. virginica*. The capsule lining is shiny. The seeds are D-shaped, shiny and regularly pitted and relatively thin.

Distribution—Part of the specimens heretofore erroneously labeled *I. versicolor* have to be reclassified as *I. virginica*. Instead of being widely distributed, this iris is found only in some of the northern counties of the state. To date the list of counties in which we unmistakably have *I. versicolor* consists of Williams, Fulton and Defiance in the Northwest, and Ashtabula, Lake, Cuyahoga, Geauga, Summit, Portage and Trumbull in the northeast, and Sandusky county in the center near the Lake. Perhaps further study will add the intervening counties along the Lake Shore, but we do not have records.

Habitats—Dispersal is by means of the floating seeds and many small streams emptying into the lake are populated with colonies of *I. versicolor*. The species spread is probably from the Great Lakes region across New York along the Mohawk and Hudson Valleys to Eastern Pennsylvania and Maryland. It is the only native species listed in the Flora of the Cayuga Basin, by Weigand and Eames (10). As a garden plant the reddish purple variety known as kermesina is without doubt selected from *I. versicolor* and is seen more frequently than any other form. Miss Sawyer (5) has reported on the cause of failure in attempting to cross *I. versicolor* and *I. pseudacorus*. She has shown in her scholarly paper that while some fusions within the embryo sac occur, the embryos fail to develop.

SUMMARY.

This account of seven species of irises growing in or near Ohio without cultivation shows the neglect of a striking group of plants in which there is an expanding public interest. That situation is also found true in the southeastern states where in addition to some of the irises named here there are a great number of other forms. A summarizing paper by Dr. Small, the Chronicle of Eastern American Iris (7) indicates the energy and enthusiasm he has devoted to the task of describing these new southern species.

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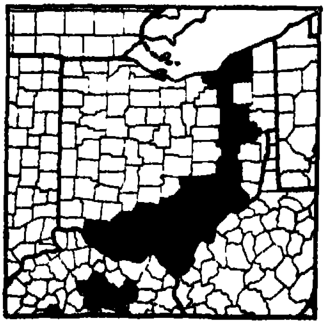
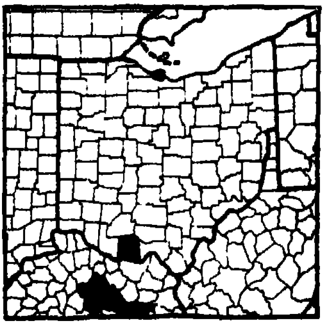
The Native Iris of Ohio
A. E. Waller

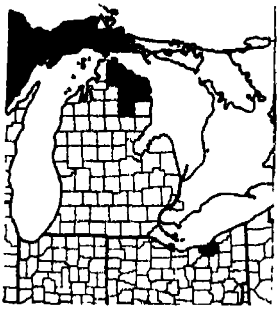
PLATE I.



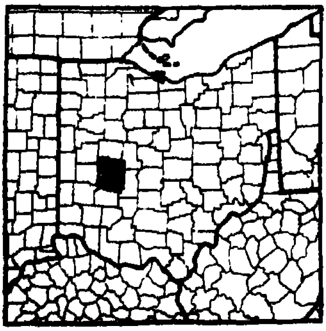
Iris cristata Ait.



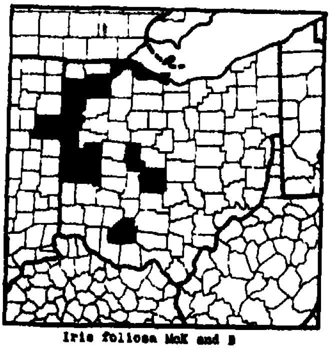
Iris verna L.



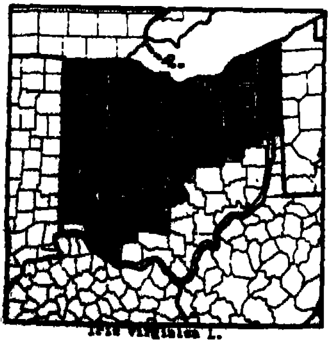
Iris lacustris Nuttall



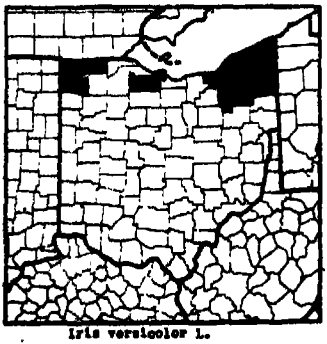
Iris fulva Ker.



Iris foliosa McK and B



Iris Virginica L.



Iris versicolor L.

OHIO MOSSES, HYPNALES.*

NELLIE F. HENDERSON.

The present paper is the fourth on the subject of the mosses of Ohio and completes the preliminary study of the plants of that group in the state. The Hypnales have been treated in the same way as the other orders were treated in former studies. With a few exceptions, the classification and nomenclature are those used by Dr. Jennings in his Mosses of Western Pennsylvania. Thamnium is included with Climacium in the Climaciaceæ, following Dr. Nichols who includes them in one family which he calls Dendroidaceæ. In parenthesis, following the name cited, are to be found the names used by authors of the usual manuals on moss.

HYPNALES.

Mosses which usually have the creeping habit, frequently with pinnate or sub-pinnate branching; archegonia situated at the tip of short special branches or buds, not at the apex; the so-called pleuricarpous mosses. Peristome usually double with the inner set of teeth alternating with the outer ones.

This order is extremely variable both in vegetative characteristics and habitats.

SYNOPSIS OF THE ORDER HYPNALES.

I. Peristome apparently simple or wanting; the inner, when present, usually incomplete.
  A. Peristome double but with an incomplete inner peristome.
    1. Inner peristome of 16 filamentous teeth, imperfectly separated; no basal membrane .... FONTINALIACEÆ (1)
    2. Inner peristome of narrow segments; basal membrane low; on trees .... NECKERACEÆ (2)
  B. Peristome wanting .... HEDWIGIACEÆ (3)
II. Peristome double, inner well-developed, cilia wanting; calyptra mitrate .... HOOKERIACEÆ (4)

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III. Peristome double, inner usually with cilia, segments keeled and often split along the median line; calyptra cucullate.
A. Sporangium usually erect and actinomorphic.
1. Sporangium non-plicate; basal membrane present; cilia rudimentary, rare, or wanting.
a. Teeth non-lamillate; inner peristome rudimentary or none, Leucodontaceæ (5)
b. Teeth with lamellæ on the inner surface.
1. Scales usually smooth.
a. Prostrate to ascending; sporophytes single, Entodontaceæ (6)
b. Dendroid; sporophytes clustered.. .Climaciaceæ (7)
2. Scales papillose .... .Leskeaceæ (8)
2. Sporangium plicate, no basal membrane, inner peristome none or of subrelate segments ....Fabroniaceæ (9)
B. Sporangium inclined to pendent, usually zygomorphic.
1. Calyptra long-rostrate, oblique ... ... Sematophyllaceæ (10)
2. Calyptra conic, obtuse or short-rostrate.
a. Alar cells quadrate, not inflated; green or hyaline, Brachytheciaceæ (11)
b. Alar cells rounded or 4-6 sided, mostly hyaline and frequently inflated. ....Hypnaceæ (12)

KEY TO THE FAMILIES OF HYPNALES.

1. Aquatic, ours long and floating with straight scales Fontinalaceæ (1)
1. Terrestrial, or if in water, with secund scales . . . 2
2. Scales papillose ... . .Leskeaceæ (8)
2. Scales smooth or only slightly papillose at the cell angles ... 3
3. Blackish; peristome wanting; on rocks; acrocarpous .. Hedwigiaceæ (3)
3. Light to dark green; peristome present; pleurocarpous... 4
4. Segments of the inner peristome rudimentary 5
4. Segments of the inner peristome keeled or often split . . 7
5. Complanate, scales undulate . .. . . Neckeraceæ (2)
5. Terete, scales not undulate 6
6. Cells of the scales elongated; small soft mosses . . Fabroniaceæ (9)
6. Cells of the scales short; coarse lax tufts; often pendent Leucodontaceæ (5)
7. Primary stems creeping, secondary stems erect and large, dendroid; sporophytes clustered.................. ..Climaciaceæ (7)
7. Primary stems prostrate or ascending; sporophytes single . . 8
8. Costate; sporangium erect, basal membrane short... ....Entodontaceæ (6)
8. Costate; sporangium usually inclined or curved, basal membrane broad.... 9
9. Cilia wanting; scales cells large; calyptra mitrate......... Hookeriaceæ (4)
9. Cilia present; scales cells small; calyptra cucullate 10
10. Costa double or furcate, short or lacking; not complanate; lid long-beaked...............................Sematophyllaceæ (10)
10. Costa single, or if double then plants complanate or with a conic or short rostrate lid.. 11
11. Costa single and reaching beyond the middle; usually glossy; often complanate, not secund..........................Brachytheciaceæ (11)
11. Costa usually short and double, sometimes wanting; if single then plants not glossy, scales often secund.......... .. ..Hypnaceæ (10)

1. *FONTINALACEÆ.*

Aquatic mosses, long and floating, dark; scales smooth, basal cells orange.

1. FONTINÀLIS (L.) Hedw

Scales ecostate, 3-seriate; sporangium almost immersed, oval to ovate, peristome orange to brownish.

1.	Scales keeled, making the gametophore appear triangular	*F. antipyretica*
1.	Scales not keeled, but concave	2
2.	Alar cells distinctly differentiated; summer scales different from those of the spring	*F. biformis*
2.	Alar cells not at all or only indistinctly differentiated	3
3.	Perichaetial scales rounded at the apex, lacerate	*F. delmarei*
3.	Perichaetial scales pointed at the apex, sometimes finely lacerate; branches attenuate	*F. delecarlica*

1. *F. antipyrética* var *gigantea* Sull. (*F. gigantea* Sull) Dark brownish to golden-green, irregularly branched; scales carinate, ovate-lanceolate to ovate, entire, acute; sporangium sub-sessile, emergent; peristome reddish. Summer. On wood or stones in running water. Adams, Hocking.

2. *F. delmarei* Ren. Card. Dull green, naked below, irregularly pinnate upper scales dense, oblong-lanceolate, erect-spreading, very concave sporangium sub-emergent. Running water. Auglaize, Portage.

3. *F. delecárlica* Br. & Sch. Slender, much branched, branches attenuate at the ends, dull, naked below; scales erect-spreading, oblong-lanceolate to lanceolate, entire or slightly toothed near the apex, concave, somewhat involute; sporangium immeresd. Summer. On stones in running water. Hocking.

4. *F. bifórmis* Sull. Dark or yellowish-green, branches dense; alar cells distinctly differentiated, summer scales differing from those of spring in being smaller and narrower, convolute above, rigid; sporangium oblong-ovate; lid conic-rostrate. Streams. Portage. ("bei Columbus in Ohio," Engler and Prantle; "Central Ohio," Lesq. and Jas.)

2. *NECKERACEÆ.*

Loosely cespitose, rather stiff and robust, primary stems creeping, secondary stems pinnately branched, erect or pendent, complanate; sporangium erect, actinomorphic.

1. NÊCKERA Hedw.

Scales ecostate, smooth; inner membrane low, cilia none; calyptra with erect hairs; annulus lacking.

1. *N. pennáta* (L.) Hedw. (*Fontinalis pennata* L.) Branches 2–3 in. long; scales acute, ovate-lanceolate, strongly undulate, entire or obscurely denticulate above, costa none or very faint; sporangium immersed, teeth sometimes apically united; calyptra small. Summer. On trunks of deciduous trees, sometimes on rocks. Champaign, Lake.

3. *HEDWÍGIACEÆ.*

Cespitose, irregularly branched with pendent branches; scales pleuriseriate, inbricated when dry, ecostate, those on the primary stalks recurved; sporangium erect, short.

1. HEDWÍGIA Ehrh.

Lax, glaucous-green above; scales entire, revolute, hyaline tipped, median basal cells yellowish; sporangium immersed, pale brown, mouth red.

1. *H. ciliàta* Ehrh. (*H. albicans* Lindb.; *Fontinalis albicans* Web.; *Anictangium ciliatum* Hedw.) Blackish below, gametophores ½–3 in. long; scales ecostate; peristome wanting. Spring. Tree trunks or noncalcaeous rocks. Butler, Clark, Fairfield, Franklin, Lake, Lawrence, Montgomery, Morgan, Scioto, Shelby.

4. *HOOKERIACEÆ.*

Small irregular, sparingly branched; scales loosely imbricated, perichaetial branch, rooting; sporangium arcuate, sub-erect to horizontal, peristome double, hypnoid, teeth lanceolate, subulate, closely articulate.

HOOKÉRIA Tayl.

Procumbent; scales acuminate, bicostate, areolation loose; outer peristome purplish, inner one orange with a basal membrane, calyptra almost entire.

1. *H. sullivàntii* C. Muell. Ms. (*H. acutifolia* Sull.) Scales ovate oblong, acute, entire, yellowish-green; fruit not known. Fairfield.

5. *LEUCODONTACEÆ.*

Stiff and robust mosses, laxly cespitose, mostly shining; primary stem creeping, radiculose, secondary stems erect, ascending or pendent; scales dense, decurrent, acute; sporangium erect, actinomorphic; peristome double, basal membrane short, cilia none; lid conic, rostrate deciduous.

1. Costa double or none, calyptra smooth . . . . *Leucodon*
1. Costa single; calyptra hairy . . . . *Forsstroemia*

1. LEÙCODON Schwaeg.

Secondary stems numerous, often pendent and curved outward; scales many-ranked, concave, margins recurved, closely imbricated when dry; inner peristome rudimentary, lid entirely covering the sporangium.

1. Scales ovate-elliptical, short-acuminate; sporangium exserted. . . *L. julaceous*
1. Scales ovate-lanceolate, longer acuminate; sporangium emergent. . *L. brachypus*

1. *L. bràchypus* Brid. Brownish to light green, ¼–2 in. long; scales plicate, entire or serrulate above; slightly secund; sporangium brown, dark-rimmed; lid obliquely rostrate. Late fall or winter. Trees and rocks. "Northern Ohio," H. C. Beardslee's catalog.

2. *L. julàceous* (L.) Sull. (*Hypnum julaceum* L.; *Pterigynandrum julaceum* Hedw.) Smaller than the preceding, julaceous when dry; never secund, scales concave, scarcely plicate, serrulate in the upper part. Fall. On tree trunks. Champaign, Clark, Fairfield, Franklin, Lake, Montgomery, Perry.

2. FORSSTRÒEMIA Lindb. (*Leptodon* Mohr.)

Green to brownish-green, usually dull; scales erect-spreading when moist, imbricated when dry, margin revolute, entire, or serrate near the apex; inner peristome none or rudimentary; lid with erect hairs.

1. Scales ecostate; sporangium scarcely exserted. . . . . *F. trichomitrium*
1. Scales costate; sporangium plainly exserted . . . . *F. ohioensis*

1. *F. trichomìtria* (Hedw.) Lindb. (*Leptodon trichomitrium* Mohr.; *Pterigynandrum trichomitrium* Hedw.) Loosely cespitose, 1–2 in. long, much branched, dull; scales dense, concave, serrate near the apex; sporangium brown, emergent. Winter. On tree trunks. Champaign, Clark, Lake, Morgan.

2. *F. ohioénsis* (Sull.) Lindb. More slender and with fewer branches than the preceding; scales costate; sporangium brown, hypophysis long, lid curved rostrate. Spring. On trees. Franklin.

6. *ENTODONTACEÆ.*

Loosely cespitose, medium to large, rather robust; scales dense, smooth or slightly papillose, costa short and double or entirely wanting; sporangium erect, straight, exserted, smooth; cilia usually lacking, calyptra smooth.

1. Cells of the scales papillose. . . . . *Schwetschkeopsis*
1. Scales smooth. 2
2. Robust; yellow-green; scales concave, narrowed at the base. . . . . *Entodon*
2. Slender, dark green; scales not narrowed 3
3. Scales acuminate, margins plane; branches curved at the tips. . . . . . *Pylaisia*
3. Scales acute, margins revolute; branches not curved at the tips . *Platygyrium*

1. SCHWETSCHKEÓPSIS Broth.

Cespitose, branches slender, yellowish-green; scales dense, concave, imbricated when dry, plicate, plane, acuminate; peristome teeth yellow, basal membrane one-third the height of the teeth, cilia rudimentary.

1. *S. denticulàta* (Sull.) Broth. (*Leskea denticulata* Sull.) Soft, flat tufts ½–1 in. deep, irregularly branched, flattened; scales ovate, denticulate, ecostate, seta yellowish-red, sporangium oblong, cilia wanting, lid conic-rostrate. Bases of trees or on rocks. Clark.

2. ÉNTODON C. Muell. (*Cylindrothecium* Br. & Sch.)

Yellowish-green, loosely cespitose, glossy, prostrate to ascending, pinnately branched; scales usually imbricated dorsally, spreading laterally, costa short and double or wanting, alar cells quadrate, hyaline, sporangium cylindrical straight, cilia lacking, basal membrane low.

1. Scales gradually acuminate . . . . *E. brevisetus*
1. Scales acute or abruptly acuminate, apiculate 2
2. Branches usually terete or julaceous . . . . *E. seductrix*
2. Branches usually flattened 3
3. Scales acute but not acuminate; teeth with more than 20 articulations, *E. compressus*
3. Scales acuminate-apiculate, teeth with less than 20 articulations, *E. cladorhizans*

1. *E. sedùctrix* (Hedw.) C. Muell. (*Neckera seductrix* Hedw.; *Cylindrothecium seductrix* Sull.) Robust, 1 in. or more long; scales appressed, oblong elliptical to ovate-apiculate, tip often reflexed, margin plane, entire or obscurely denticulate near the apex; seta purple, sporangium golden-brown, hypophysis abrupt, peristome inserted below the mouth, teeth papillose. Autumn. Rotten wood, rocks, bases of trees, and soil. Clark, Fairfield, Franklin, Greene, Hamilton, Hardin.

2. *E. brevisètus* (Hook. & Wils) Jaeg. (*Cylindrothecium brevisetum* Wils) Soft slender; scales acuminate, long; seta three-eighths to one-half in. long, copper-colored; sporangium golden-brown, neck tapering, segments of the inner peristome adherent to the teeth; lid small, obliquely rostrate. Autumn. On logs. Champaign, Clark.

3. *E. cladorhìzans* (Hedw.) C. Muell. (*Cylindrothecium cladorhizans* Schimp.; *Neckera cladorhizans* Hedw). Large flattened tufts, very glossy; scales oblong-ovate, faintly serrulate near the apex, apex often reflexed; teeth not papillose; seta castaneous, lustrous, base of the sporangium abrupt. Autumn and early winter. On logs. Clark.

4. *E. comprèssus* (Hedw.) C. Muell. (*Cylìndrothecium compressum* Br. & Sch). Gametophores much compressed, more slender than the last species; scales entire; sporangium ovate to elliptical, short, lid curved, rostrate, peristome teeth closely articulate, papillose. Autumn and early winter. Bases of trees. Franklin.

3. PLATYGYRIUM Br. & Sch.

Cespitose in flat mats, dark to bright green; scales decurrent, acute to acuminate, ecostate; lid conic.

1. *P. rèpens* (Brid.) Br. & Sch. (*Pterogonium repens* Schwaeg.; *Anomodon repens* Fuern.; *Cylindrothecium repens* DeNot). Primary stems creeping, radiculose below, branches short, julaceous; scales imbricate when dry, margins revolute below; seta about ¾ in. long, copper-colored, lustrous, sporangium golden brown, cylindrical, hypophysis tapering, teeth hyaline bordered. Autumn. Tree trunks and decaying wood. Champaign, Clark, Franklin, Lake.

4. PYLAÌSIA Br. & Sch.

Flatly cespitose, branches short and curved at the tips when dry; scales imbricated when dry, erect-spreading and secund when moist, concave, ovate to ovate-lanceolate, acuminate, costa double and very short or none; seta ¼-½ in. long, sporangium erect, cylindric, cilia none, segments often adherent to the teeth.

1. Segments of endostome free from the teeth, membrane distinct; operculum beaked.. ......*P. subdenticulata*
1. Segments adherent to the teeth, lid conic; membrane low or wanting...... 2
2. Segments completely adherent; quadrate alar cells few ... .*P. intricata*
2. Segments partly adherent; quadrate cells bordering one-third of the scales.. .. ..*P. schimperi*

1 *P. intricàta* (Hedw.) Ren. & Card. (*P. velutina* Br. & Sch.; *Pylaisiella velutina* Lindb.; *Pterygynandrum intricatum* Hedw.). Light, flat, dense mats; scales lanceolate, long-acuminate, falcate-secund, ecostate; seta straight, light brown, about three-sixteenths inches long; sporangium ovoid-cylindric, castaneous. Autumn. On stumps and bases of trees. Champaign, Clark, Franklin.

2. *P. schìmperi* Card. (*P. intricata* Br. & Sch.; *Pylaisiella intricata* Grout). Thin dense mats, dark green; scales dense, decidedly falcate-secund, ovate-lanceolate, long-acuminate, alar cells yellowish, incrassate; seta about ½ in. long, reddish; sporangium ovoid-oblong, small-mouthed. Autumn. Tree trunks and decaying wood. Clark, Lake, Perry.

3. *P. subdenticulàta* Br. & Sch. (*Pylaisia denticulata* Sull.). Yellowish-green, flat mats, much branched; scales ovate-lanceolate, ecostate, or costa very faint and short, entire below, sub-denticulate above; sporangium oblong. Autumn. Tree trunks, wood and stones. Clark.

7. *CLIMACIACEÆ.*

Large mosses, with erect branches from a creeping caudex, dendroid; scales 3 or more ranked, smooth, rarely slightly papillose at the angles; sporophytes clustered, peristome with articulate teeth, segments of the inner peristome carinate, often split along the keel.

1. Sporangium erect and actinomorphic; peristome without cilia ....*Climacium*
1. Sporangium curved, cernuous; peristome with cilia...............*Thamnium*

1. CLIMÀCIUM Web. & Mohr.

Large, tree-like, branchlets simple and clustered near the top of the main erect branch, papaphyllia numerous; scales decurrent, auricles lanceolate, acute, sharply serrate in the outer portion; sporangium cylindric, castaneous, teeth with a dark red border, inner peristome orange, calyptra long, enclosing the sporangium, split at one side.

1. *C. americànum* Brid. Loosely cespitose, 2–5 in. deep, yellowish-green, lustrous, primary branches erect bearing ovate, closely imbricated scales below and a tuft of branchlets above; branch scales broad lanceolate, serrate in the outer portion, erect-spreading, imbricated when dry, costa strong, almost to the apex; seta erect, 1–1½ in. long, castaneous, sporangium erect or slightly curved, slightly constricted below the mouth when dry, lid slender rostrate. Autumn. Soil, rocks, and logs in swamps. Adams, Champaign, Clinton, Franklin, Galion, Hancock, Meigs, Montgomery, Ottawa, Portage, Richland, Ross, Scioto, Seneca, Shelby, Stark, Summit, Vinton, Williams.

2. THAMNIUM Br. & Sch.

Robust mosses with erect branches, tree-like, with a cluster of branchlets at the top, spreading, curved; scales erect-spreading, serrate, costa strong, ending below the apex; seta red, smooth sporangium inclined to horizontal, somewhat arcuate, gibbous peristome yellow, teeth bordered, lid, conic-rostrate, calyptra cucullate.

1. *T. alleghenіensis* (C. Muell.) Br. & Sch. (*Hypnum allegheniensis* C. Muell.; *Porotrichum allegheniensis* Grout). Large, 1½–3 in. deep, bright or pale green, lustrous; scales oblong-elliptical, short acuminate, or acute base narrow, margin plane, sharply serrate in the outer portion; seta about ½ in. long, sporangium castaneous, oblong cylindric, lid one-third to one-half as long as the urn. Autumn. Dripping ledges in ravines. Greene, Lake.

8. *LESKEACEÆ.*

Cespitose, usually dull and stiff; scales rarely uniform, usually costate; basal portions smoother than the outer.

1. Primary stems stoloniferous; archegonial clusters borne on the branches. 2
1. Not stoloniferous; archegonial clusters borne on the main stems 3
2. Slender mosses; costa ending at or below the middle of the scale, *Haplohymenium*
2. More or less robust mosses; costa reaching nearly or quite to the apex, *Anomodon*
3. Costa single, strong, nearly or quite to the apex 4
3. Costa short, single or double or lacking 8
4. Scales of primary stems and branches similar; 2–4 or no papillæ on the terminal cell. 5
4. Scales of primary stems and branches dissimilar; one papilla on the terminal cell 7
5. Sporangium erect or nearly so; cilia rudimentary . . . . *Leskea*
5. Sporangium arcuate; cilia complete 6
6. Cells smooth or slightly papillose; cilia smooth . . . . *Elodium*
6. Cells strongly papillose on both surfaces; cilia nodose or appendiculate, *Haplocladium*
7. Medium-sized mosses; paraphyllia branched; cells with 2–5 papillæ on each surface; lid short-rostrate . . . . *Rauia*
7. Paraphyllia simple or if branched then large mosses, lid long-rostrate, *Thuidium*
8. Irregularly bushy branched; costa wanting or very short; cilia two *Myurella*
8. Pinnately simple branched; costa distinct; cilia none . . . . *Thelia*

1. THELIA Sull.

Densely cespitose, dull, glaucous, julaceous, creeping, branches closely pinnate; scales imbricated, concave, broadly ovate, margins with long slender teeth, costa short, cells each with one large dorsal papilla; perichaetial scales with long marginal cilia, oblong; seta slender, reddish; sporangium erect, actinomorphic, inner peristome with a basal membrane and short segments.

1\. Papillæ simple, curved . . . . *T. hirtella*
1\. Papillæ branched or forked 2
2\. On trees; scales ciliated . . . . *T. asperella*
2\. On soil; scales not ciliated . . . . *T. lescurii*

1. *T. hirtèlla* (Hedw.) Lindb (*Pterigynandrum hirtellum* Hedw.; *Hypnun hirtellum* C. Muell.) Thin mats, light above, radiculose below; scales sub-orbicular, margins spinulose-dentate above, ciliate below, abruptly acuminate, lid rostrate. Autumn. Tree trunks and roots. Champaign, Clark, Franklin, Lake, Montgomery.

2. *T. asperèlla* Sull. (*Leska asprella* Br. & Sch.) Light glaucous green: scales long-ciliate, long-acuminate; seta red, about ½ in. long; sporangium oblong cylindric, pale; peristome whitish. Autumn. Tree bases. Clark, Franklin, Montgomery, Ottawa.

3. *T. lescùrii* Sull Fasciculately branched, light claucous green; scales short-acuminate: seta reddish, over ½ in. long; sporangium reddish-brown. Autumn. On sandy soil and rocks. Not reported, but is probably to be found.

2. MYURÈLLA Br. & Sch.

Soft loose mats of very slender branches, irregularly branched, light to bright bluish-green, sometimes flagellate at the apex; scales imbricate, concave, broad-ovate, smooth or dorsally mamillate; seta red, sporangium erect or slightly inclined when old, constricted below the mouth, cilia present.

1. Scales serrulate-dentate; obtuse or short-apiculate	*M. julaceae*
1. Scales spinulose-dentate abruptly long-acuminate	*M. gracilis*

1. *M. julàcea* (Vill.) Br. & Sch. (*Hypnum julaceum* Vill.) Light green, branches filiform, julaceous; scales dense, imbricated, costa indistinct; sporangium rarely found, oblong-elliptical; peristome yellow. July-August. In crevices of rocks. Not reported.

2. *M. gràcilis* (Weinm) Lindb. (*M. careyana* Sull.) Pale, glaucous-green; scales not so dense and more spreading than in the preceding species; papillæ large and simple, costa short; rarely fruiting. Damp crevices in limestone. Cuyahoga, Greene.

3. HAPLOYMÈNIUM Doz. & Molk.

Stiff, stems creeping with pinnate branches forming a thin mat; upper scales spreading to squarrose, imbricated when dry; base of scales concave, clasping, more or less abruptly narrowed, broadly ligulate, entire, costa to the middle of the scale or beyond; sporangium brown, erect.

1. *H. trìstes* (Cesat. Lindb.) (*Leskea tristis* Cesat.; *Anomodon tristis* Sull.) Small, mats thin, very slender, dull green, irregularly pinnate; scales imbricated when dry, spreading-squarrose when moist, blunt, several papillæ on each face of the cell; fruit not yet found. Champaign, Clark, Lake.

4. ANOMÓDON Hook. & Taylor.

Coarse, robust, lax mats, dull; primary stems creeping, secondary erect to ascending; scales dense, plane, densely papillose on both surfaces; costa simple and strong; seta erect, sporangium erect, not narrowed below the mouth.

1. Branches attenuate . . . . *A. attenuatus*
1. Branches not attenuate 2
2. Scales norrowly acuminate, ending in a hair point . . *A. rostratus*
2. Scales ligulate from a broader base 3
3. Scales apiculate, auricled . . . *A. apiculatus*
3. Scales with rounded apex, not auricled . . . *A. minor*

1. *A apiculàtus* Br & Sch. (*Leskea apiculata* Schimp.; ***Hypnum rugelii*** C. Muell) Somewhat glaucous, reddish-brown below, stems 1-2 in. long, upper margins involute, entire, crisped when dry, costa ending below the apex; seta about ¼ in long, brown; sporangium ovate-cylindrical, castaneous; peristome segments rudimentary, basal membrane low. Autumn. On shaded rocks and bases of trees. Lake.

2. *A. minor* (Hedw) Fuern. (*A obtusifolius* Br & Sch.) Branches 1-2 in long, claucous, brownish when old; scales somewhat complanate, entire, densely papillose, costa strong, ending below the apex; seta ¼–½ in., sporangium cylindric-oblong, mouth contracted, lid conic, oblique-rostrate, peristome hyaline. Late autumn and winter. Bases of trees and rocks. Clark, Franklin, Lake.

3. *A. attenuàtus* (Schreb.) Hueben. (*Leskea attenuata* Hedw.; *Hypnum attenuatum* Schreb.) Slender mosses, more densely tufted than the two preceding species, wide, many branches flagellate; scales lanceolate, acute, minutely apiculate, costa ending below the apex; seta about ⅜ in., brown, sporangium cylindric, castaneous, peristome segments narrow. Autumn. Rocks, trees, stumps in the shade Belmont, Clark, Fairfield, Hamilton, Hancock, Lake, Seneca.

4. *A. rostràtus* (Hedw.) Schimp. (*Leskea rostrata* Hedw.) Wide, dense tufts of very slender branches, yellowish-green; scales long-acuminate complanate, margins often recurved; seta ¼–⅜ in., brown; sporangium oblong-ovoid, brown, short; lid conic, basal membrane high. Autumn. On rocks and at the bases of trees. Clark, Fairfield, Franklin, Portage, Seneca, Union, Williams.

5. LÈSKEA Hedw.

Small, loosely cespitose, dark green mosses, stalks prostrate with short erect branches; scales dense, imbricated when dry, sporangium oblong-cylindrical, cilia rudimentary or none, basal membrane low; calytra smooth, cucullate.

1. Scales ovate-lanceolate, acute to long-acuminate, somewhat secund, *L. polycarpa*
1. Scales ovate, acute to obtuse, not secund. 2
2. Scales revolute, 2-plicate. . . . *L. gracilescens*
2. Scales plane, non-plicate . . . . *L. obscura*

1. *L. polycàrpa* Ehre Hedw. (*Hypnum medium* Dicks.) Mats thin, dull green; scales loosely imbricated when dry, entire, basal margins recurved, apex often obliquely pointed; seta about ½ in., sporangium light brown. Summer. Bark, wet wood or stones or damp earth. Ashtabula, Franklin, Montgomery, Morgan.

2. *L. gracilèscens* Hedw. Branches erect, simple, numerous; scales closely imbricated when dry, acute, entire; peristome whitish. Early summer. Moist tree bases and wood. Not reported.

3. *L. obscura* Hedw. (*L. nervosa* Sull.; *L. microcarpa* Schimp.) Erect branches, divided and fewer than in the preceding species; scales spreading when moist, incurved, appressed when dry, apex sub-acute to obtuse, concave, entire or serrulate; seta ½–¾ in., peristome yellowish. Early summer. Wet stones, logs and roots of trees. Lake, Morgan.

6. RÀUIA Aust.

Dull, dark green, pinnately branched, julaceous; scales erect-spreading, imbricated when dry, stem scales triangular to cordate, entire, long-acuminate, branch scales ovate-lanceolate, appressed, pale, seta slender, reddish; sporangium light brown, inner peristome with wide basal membrane, lid conic, short-rostrate.

1. *R. scita* Aust. (*Hypnum scitum* Beauv.; *Thuidium scitum* Aust.) Densely pinnate; sporangium oblong-cylindrical, straight or slightly arcuate, erect or inclined. Teeth pale. Autumn and winter. Bases of trees. Clark, Erie.

2. *R. scita aestivàle* (Lesq. & Jas.) (*Thuidum aestivum* Aust.; *T. scitum* var. *aestivale* Aust.; *Hypnum scitum aestivale* Lesq. & Jas.) Less densely branched sporangium, horizontal, teeth yellowish, sporangium abruptly and very short rostrate. Bases of trees. Autumn and winter. Clark, Erie.

7. HAPLOCLÀDIUM C. Muell.

Thin mats, dull, creeping pinnately branched, branches usually simple, ascending; scales erect-spreading when moist, appressed when dry; paraphyllia branched, numerous; scales lanceolate to lance-subulate, base revolute, upper part faintly serrate to entire, costa strong, almost or quite to the tip, acute to acuminate; seta ½–¾ in. long, reddish; sporangium inclined to horizontal, more or less arcuate, contracted below the mouth when dry, peristome yellow, cilia complete, calyptra conic.

1. Scales ovate, abruptly rounded, short-acuminate.............. *H. virginianum*
1. Scales ovate, gradually long-acuminate...................... *H. microphyllum*

1. *H. virginiànum* (Brid.) Broth. (*Thuidium virginianum* Lindb.; *Hypnum gracile* var. *lancastriense* Sull. & Lesq.; *Thuidium gracile lancastriense* Card.) Dark green; scales ovate, concave, serrulate in the outer part, erose-dentate below, costa into the acumen; perichaetial scales light, lanceolate; seta castaneous, sporangium castaneous, curved, constricted below the mouth when dry; lid short-beaked. Spring. Ground or roots of trees in the open woods. Reported from Ohio by Lesquereux.

2. *H. microphyllum* (Sw.) Broth. (*Hypnum gracile* Br. & Sch.; *Thuidium microphyllum* Best; *Thuidium gracile* Br. & Sch.) Pale or yellowish-green; pinnately branched; scales ovate to lance-ovate, margins entire or sinuate-dentate, costa almost to the tip; seta about ¾ in. long, castaneous, sporangium light brown, oblong, curved, lid short-conic. Earth, rotten wood, stones and tree bases. Summer, Clark.

8. THUÍDIUM Br. & Sch.

Slender to robust, stiff, dull to light green, pinnately branching to form frond-like gametophores; scales erect-spreading when moist, incurved or appressed when dry, plicate, base narrow and recurrent, branch scales lance-ovate, perichaetial scales paler, lanceolate; sporangium more or less arcuate, constricted below the mouth when dry; seta slender, red or castaneous; lid conic, oblique rostrate; calyptra cucullate.

1. Plants less than 2 in.; paraphyllia unbranched, few 2
1. Plants over 2 in.; paraphyllia numerous, branched 3
2. Branches papillose; ⅛–⅜ in. tall .... *T. pygmaeum*
2. Branches smooth; ⅛–1⅜ in. tall .... *T. minutulum*
3. Simply pinnately branched; erect or ascending in tufts 4
3. Bipinnately branched; prostrate in mats 5
4. Plants rigid; on dry stones or sterile soil; apical cell of the branch scale papillose .... *T. abietinum*
4. Plants soft on wet swampy soil; a spical cell of the branch scale not papillose .... *T. blandowii*
5. Scales recurved, spreading when moist, margin plane, costa percurrent, *T. recognitum*
5. Scales erect-spreading when moist, margin revolute, costa ending below the apex .... *T. delicatulum*

1. *T. pygmàeum* Br. & Sch. (*Hypnum pygmaeum* Sull.) Delicate, ⅛–¼ in., creeping, forming delicate patterns over the substratum, branches papillose, paraphyllia on the branches; scales triangular-ovate; seta ¼–½ in., sporangium oblong-ovate, calyptra oblique-rostrate. Late summer and early autumn. Rocks and earth in moist shade. Ashtabula, Clark, Franklin.

2. *T. minùtulum* (Hedw.) Br. & Sch. (*Hypnum minutulum* Hedw.) Irregularly branched, branches smooth, paraphyllia on the branches and main stems; stem scales distant, deltoid, acuminate, costa to near the apex, branch scales ovate-acuminate, costa shorter, perichaetial scales lanceolate; seta about ¾ in., copper-colored, sporangium ovate-oblong, cernuous, operculum oblique-rostrate. Autumn. Rotten wood and bases of trees. Clark.

3. *T. delicàtulum* (L.) Mitt. (*Hypnum delicatulum* L.) "Common Fern Moss." Thick mats, bright green at the tips of the gametophores, darker below, bipinnately or tripinnately branched, forming fronds, procumbent; stem scales triangular, margins somewhat recurved, erect-spreading when moist, appressed when dry, serrate, acuminate, margins somewhat recurved; branch scales broad-ovate, smaller; perichaetial scales ciliate on the margins; seta 1–1½ in. long, lustrous, castaneous; sporangium oblong, arcuate, castaneous, operculum conic-rostrate. Winter. Soil, rocks or wood in moist woods. Champaign, Lake, Vinton.

4. *T. recògnitum* (Hedw.) Lindb. (*Hypnum recognitum* Hedw.; *Thuidium delicatulum* Br. & Sch.) Yellowish-green, mostly bipinnately branched, stem-scales broadly deltoid, auricled, cordate, abruptly acuminate, spreading-recurved when moist, sulcate when dry, margins usually plane; perichaetial scales without cilia; seta 1–1½ in long, lustrous sporangium oblong, arcuate, castaneous, lid short-rostrate.

Summer. Soil, wood, and rocks in moist woods. Champaign, Clinton, Fairfield, Franklin, Licking, Lawrence, Logan, Morgan, Summit.

5. *T. abietìnum* (L.) Br. & Sch. (*Hypnum abietinum* L.) "Wiry Fern Moss." Large stiff mosses forming loose mats 2-3 in. deep, simple pinnate; paraphyllia short, dark green; stem scales ovate, acuminate, biplicate, serrulate, recurved, appressed when dry, costa to ¾ the length of the scale; sporangium narrow, cylindric, cernuous Not seen in fruit. On dry rocky ledges and sterile soil. Not reported from Ohio.

6. *T. blandowii* (Web. & Mohr.) Br. & Sch. (*Hypnum blandòwii* Web. & Mohr.) Pale or yellowish-green, in soft loose mats, 2-4 in. deep, paraphyllia long and branched, numerous, gametophores simply pinnate, branches slender; stem scales acuminate, ovate-deltate, dense, thin, costa ½ the length of the scale; seta copper-colored, 1½-2 in. long; sporangium curved, oblong-cylindric, contracted below the mouth when old, lid conic Summer. Wet swampy soil. Reported by Sullivant from "Ohio."

9. ELÒDIUM (Sull.) Warnst.

Large yellowish-green to brownish mosses, simple or pinnately branching; scales erect-spreading when moist, appressed when dry, concave, plicate, acuminate, revolute, costa ending below the apex; perichaetial scales narrow, erect; sporangium arcuate, oblong-cylindrical, brown, peristome yellow, teeth confluent at the base, hyaline bordered, basal membrane high, lid conic, calyptra cucullate.

1. *E. paludòsum* (Sull.) Loeske. (*Hypnum paludosum* Sull.; *Thuidium paludosum* Jaeg. & Sauer.) Irregularly pinnate, yellowish-green, creeping, branches erect or ascending, 1-1½ in. long; scales oblong-lanceolate, only slightly papillose, paraphyllia numerous, branched; seta ½-1 in long, reddish, sporangium inclined to horizontal, about 3 to 1; operculum apiculate. Winter. Swampy ground. Fulton.

9. *FABRONIACEÆ.*

Bright or light green, cespitose, red radiculose, small soft mosses; scales dense, appressed when dry, non-plicate, erect-spreading when moist, ovate to lanceolate; sporangium exserted, erect, actinomorphic, ovoid to short-cylindrical; calyptra cucullate, smooth.

1. Scales with simple costa; inner peristome of filiform divisions *Anacamptodon*
1. Scales ecostate; inner peristome wanting.... ... .*Habrodon*

1. ANACÀMPTODON Brid.

Scales somewhat secund, ovate, long-acuminate, entire, costa to above the middle, oblong; sporangium with short neck, constricted below the mouth when dry; inner peristome without basal membrane.

1. *A. splachnoìdes* (Froel.) Brid. (*Campylodontium hypnoides* Schwaeg.; *Neckera splachnoides* Schwaeg.) Bright green, seta and sporangium reddish-brown, teeth lighter brown, in pairs, reflexed when dry. Early summer. On moist decaying wood or decaying places in living trees. Clark.

2 HÁBRODON Schimp.

Creeping, irregularly branched, leafy branches julaceous; scales entire or slightly crenulate, cell walls thick; sporangium ovoid.

1. ***H. purpusillus*** (DeNot) Lindb. (***H. notarisii*** Schimp.) "Tree trunks in central Ohio." Reported by W. S. Sullivant (L & J. Manual). No specimen in the herbarium

10. *SEMATOPHYLLACEÆ*

Cespitose, often lustrous, creeping to ascending, irregularly branched; scales pleuriseriate, costa double, very short or none, one row of basal cells inflated; inner peristome free, basal membrane high; antheridial clusters gemmiform.

1. RAPHIDIOSTÈGIUM (Br & Sch.) DeNot.

Densely cespitose, creeping, irregularly pinnately branched; scales erect-spreading, non-plicate, concave, ecostate or costa double and very short; sporangium suberect to horizontal, peristome hypnoid, calyptra long-subulate-rostrate, teeth yellowish, hyaline-bordered.

1. Plants on trees; sporangium erect or nearly so; scales secund . . . *R. adnatum*
1. Plants on stones; sporangium inclined to horizontal, scales erect-spreading or slightly secund . . . . . *R. carolinianum*

1. ***R. adnàtum*** (Mx.) Br. & Sch. (***Leskea adnata*** Mx.; ***Rhyncostegium microcarpum*** Jaeg.; ***Hypnum microcarpum*** C. Muell.; ***Sematophyllum adnatum*** E. G. Britt.) Small, thin mats, green to golden-green, branches often curved, short, suberect; scales dense, imbricated when dry, oblong-lanceolate, short-acuminate, margin reflexed, almost entire; sporangium erect, not at all or only slightly zygomorphic, oblong-ovate, mouth reddish, slightly constricted below, castaneous, seta about ¼ in. long. Summer and early autumn. Champaign.

2. ***R. carolinànum*** (C. Muell.) Jaeg. (***Hypnum carolinianum*** C. Muell.; ***Sematophyllum carolinianum*** E. G. Britt.; ***Hypnum demissum*** Wils var. ***carolinianum*** Lesq. & Jas.) Dark yellowish or dirty green, small tufts, branches ascending to erect; scales imbricated, sub-secund or complanate, non-plicate, ovate-lanceolate, slightly serrulate near the apex, margins reflexed; seta castaneous, about ½ in. long, sporangium curved, constricted below the mouth when dry, mouth red. Summer and early autumn. Wet, non-calcareous rocks in ravines. Clark, Summit.

11. *BRACHYTHECIACEÆ.*

Creeping, branches procumbent or ascending; scales erect-spreading to appressed, often complanate, sometimes secund; stem and branch scales unlike, plicate or sulcate, ovate to lanceolate, acuminate, alar cells often hyaline, not inflated, paraphyses filiform; sporangium ovoid, cernóus, lid conic to long-rostrate, antheridia in gemmiform clusters.

1. Sporangium erect and actinomorphic . . . . *Homalotheciella*
1. Sporangium inclined to horizontal, zygomorphic. 2
2. Scales deeply grooved . . . . *Camptothecium*
2. Scales not at all or only slightly grooved 3
3. Alar cells differentiated; lid conic. . . . . *Brachythecium*
3. Alar cells few or none; lid long-beaked 4
4. Cells elongated, rhomboidal or hexagonal, somewhat rough. . . . . *Brynhia*
4. Cells short, smooth 5
5. Complanate; seta smooth . . . . *Rhynchostegium*
5. Scales spreading or imbricated; seta usually rough 6
6. Scales very concave; abruptly piliferous-acuminate . . . . *Cirriphyllum*
6. Scales plane or slightly concave; gradually acuminate, not piliferous. . . . 7
7. Plicate, usually somewhat concave . . . . *Eurynchium*
7. Non-plicate, plane or only slightly concave, seta smooth in our species, *Oxyrynchium*

1. HOMALOTHECIÉLLA (Card.) Broth.

Small, soft, glossy mosses, loosely cespitose with creeping stems, branches short, numerous, curved at the ends when dry; scales erect-spreading when moist, imbricated when dry, concave, non-plicate, lanceolate to acuminate, costa simple, alar cells green, quadrate; seta castaneous, rough; inner peristome shorter than the outer, yellow, cilia none; lid long-rostrate.

1. *H. subcapillàta* (Hedw) Broth. (*Homalothecium subcapillatum* Sull.) Light yellowish green mats; scales smooth, costa ending near the middle, abruptly long-acuminate, somewhat serrate above, alar cells extending up ⅓ of the margin; sporangium slightly curved and constricted below the mouth, somewhat gibbous, peristome teeth red with a median pellucid line, segments adhering to the teeth. Autumn. Tree trunks and logs in the woods. Clark.

2. CAMPTOTHÈCIUM Br. & Sch.

Large, loosely cespitose, yellowish-green glossy mosses; gametophores branching pinnately; scales erect-spreading when moist, concave, strongly plicate, ovate-lanceolate, acuminate, serrulate, costa simple, alar cells quadrate; seta castaneous, usually rough, sporangium cernuous, gibbous; peristome teeth confluent, bordered, inner peristome free, the same length as the outer.

1. *C. nitens* (Schreb.) Schimp. (*Hypnum nitens* Schreb.) Bright yellowish, lustrous, with brown felted radicles 2–3 in. tall; scales elongate-lanceolate, margins revolute, alar cells few, somewhat secund; sporangium arcuate. Late spring. Wet, swampy soil. Reported from southern Ohio by Lesquereux. No specimen in the herbarium.

3. BRACHYTHÈCIUM Br. & Sch.

Wide flat mats, creeping or almost procumbent; scales dense, stem scales erect-spreading to spreading, plicate, lanceolate, acuminate, margins plane, costa simple, alar cells quadrate to somewhat elongated, not well defined; sporangium cernuous, gibbous, horizontal, ovate to oblong, dark colored; peristome teeth confluent at the base, inner peristome free, yellowish, basal membrane wide, cilia nodose or appendiculate, lid conic.

1. Seta smooth 2
1. Seta rough, at least above 5
2. Scales not plicate or striate; lanceolate to lance-ovate . . . . . *B. acutum*
2. Scales plicate, ovate-lanceolate to ovate 3
3. Sporangium erect, straight or nearly so; cilia rudimentary or lacking, *B. acuminatum*
3. Sporangium more or less inclined; cernuous; cilia well-developed . . 4
4. Sporangium sub-erect; only slightly curved, 3-4: 1 . . . . . *B. oxycladonm*
4. Sporangium strongly inclined; much curved, 2-3: 1 . . . *B. salebrosum*
5. Costa percurrent or nearly so . . . . *B. populeum*
5. Costa ending near the middle 6
6. Seta rough only above; scales ovate-lanceolate 7
6. Seta rough throughout; scales ovate 8
7. Scales plicate, long and slenderly acuminate . . . . . *B. campestre*
7. Scales non-plicate, shorter, often secund . . . *B. plumosum*
8. Very short-acuminate, dendroid, basal cells hyaline, well defined, forming auricles . . . . *B. rivulare*
8. Gradually slender-acuminate, non-dendroid, basal cells greenish, not distinctly auricled . . . . *B rutabulum*

1. *B. salebrósum* (Hoffm.) Br. & Sch. (*Hypnum salebrosum* Hoffm.; *Hypnum plumosum* Huds.) Yellowish-green mats, irregularly branched; scale ovate-lanceolate, abruptly acuminate, concave, decurrent; seta about ¾ in. long, castaneous, twisted, sporangium arcuate, horizontal, inner peristome about the same height as the teeth, cilia nodose, basal membrane one-third the height of the teeth. Autumn. Cosmopolitan in shady places. "Common," H. C. Beardsley's catalog. No specimen.

2. *B. campéstre* (Bruch.) Br. & Sch. (*Hypnum campestre* Bruch.) Similar to *B. salebrosem* except for the seta's being rough above. Winter Earth, rocks and rotting logs. Not reported.

3. *B. oxyclàdon* (Brid.) Jaeg. (*B. laetum* Br. & Sch.; *Hypnum oxycladon* Brid.) Yellowish-green, broadly and laxly cespitose; scales lanceolate, gradually acuminate, deeply plicate, margins finely serrulate, decurrent; seta castaneous, ¾–1 in. long, sporangium brown. Autumn. Rocks, earth and tree bases in woods. Clark, Perry.

4. *B. acùtum* (Mitt.) Sull (*Hypnum acutum* Mitt.) Glossy, yellowish-green lax, branchlets short; scales erect-spreading, not striate or plicate, only slightly concave, finely serrulate to entire; auricled; seta flexuous, sporangium ovoid-oblong, inclined to horizontal, somewhat arcuate. Late fall. Earth and rotting logs in swampy woods. Champaign, Lake.

5. *B. rutábulum* (L.) Br. & Sch. (*Hypnum rutabulum* L.) Robust, glossy, yellowish-green, creeping, branches somewhat attenuate; scales ovate, acuminate, slightly decurrent, faintly serrulate, scarcely concave; seta castaneous, about 1 in. in length, sporangium castaneous, oblong-ovoid, arcuate, almost horizontal, teeth slender, basal membrane one-half the height of the segments Early winter. In moist woods on earth, stones, logs and tree bases. Champaign, Clark, Erie.

6. *B. rivuláre* (Bruch.) Br. & Sch. (*Hypnum rivulare* Bruch.; *B. flavescens* Lindb.) Robust, bright to yellowish-green, variable, branches somewhat erect and dendroid; scales distant, ovate, erect-spreading, concave, decurrent, acute to acuminate, plicate, branch

scales more ovate-lanceolate; seta ¾–1 in. in length, castaneous, sporangium arcuate, strongly inclined to horizontal, lid acuminate. Early winter. On rocks in water or the margin of streams where they are often submerged Lake, Licking.

7. *B. popùleum* (Hedw.) Br. & Sch. (*Hypnum populeum* Hedw) Slender, densely cespitose, dark to yellowish-green, creeping with branches ascending and curved; scales erect to erect-spreading when moist, nonstriate, imbricated when dry, ovate-lanceolate, slenderly acuminate, slightly decurrent, costa strong nearly to the apex, margin serrate to almost entire; seta castaneous, about ½ in long, sporangium curved, ovoid-oblong. On shady soil, rocks, roots and bases of trees in woods. Not reported.

8. *B. acuminàtum* (Hedw) Kindb. (*Leskea acuminata* Hedw.; *Hypnum acuminatum* Beauv.) Densely cespitose, glossy, dark to yellowish-green, prostrate creeping, branches short, plumose to somewhat julaceous; scales erect-spreading, narrowed at the base, somewhat decurrent, slightly plicate, costa to the middle, alar cells quadrate; seta castaneous, about ½ in. long, sporangium cylindrical, erect, slightly arcuate, teeth narrow, hyaline above, cilia rudimentary or none. Autumn. Decaying wood, rocks, roots and bases of trees in the woods. Clark, Franklin, Perry.

9. *B. plumòsum* (Sw.) Br. & Sch. (*Hypnum plumosum* Sw.; *Hypnum flagellare* Hedw.; *B. flagellare* Jenn.) Loosely cespitose, brown beneath, creeping with ascending to erect branches; scales erect or imbricated, lance-ovate, abruptly acuminate, costa ending near the middle, decurrent, serrate to entire, slightly decurrent; seta castaneous, stout; sporangium oblong-ovoid, dark, horizontal to almost erect, peristome teeth confluent at the base, hyaline at the tips. Autumn. Wet rocks in streams. Not reported.

4. CIRRIPHYLLUM Grout.

Widely cespitose, glossy, light or yellowish green, robust; branches julaceous, often with flagellæ; scales uniform, very concave, ovate to oblong-ovate, base decurrent, margin plane, costa simple to the middle of the scale; sporangium cernuous to horizontal, ovoid to oblong-ovoid, lid long-rostrate, conic.

1. Robust; acumination short; seta smooth . . . . *C. boscii*
1. More slender; acumination one-half as long as the rest of the scale; seta rough . . . . *C. piliferum*

1. *C. pilíferum* (Schreb.) Grout. (*Hypnum piliferum* Schreb.; *Eurynchium piliferum* Br. & Sch.) Yellowish-green, prostrate, creeping to 5 in. long, rather distinctly pinnate; scales oblong-ovate, abruptly piliferous acuminate, costa wide, alar cells enlarged; seta ¼–1 in., sporangium arcuate, strongly so when dry, segments equalling the teeth in length, cilia non-appendiculate. Autumn; rarely fruiting. Wet soil and bases of trees in woods and swamps. Champaign.

2. *C. bóscii* (Schweg.) Grout. (*H. boscii* Schwaeg.; *Eurynchium boscii* Jaeg.) Loose deep mats, yellowish-green, dark below, prostrate with erect simple branches to 5 in. long; scales oblong-ovate, abruptly

acuminate, accumination twisted, costa simple, or short and double, alar cells and indistinct group, seta 1 in. or more long, golden-brown, sporangium slightly arcuate, inclined. Autumn. Soil or rocks in moist open woods or fields. Champaign, Clark, Fairfield, Lawrence, Muskingum.

5. EURYNCHIUM Br. & Sch.

Cespitose, yellowish-green or green; scales rather dense, usually plicate, costa to the middle or farther, somewhat decurrent, margin plane, serrate; lid with a long needle-like beak.

1. Scales spreading; branches elongated . *E. pulchellum*
1. Scales appressed-imbricate; branches julaceous, short . *E. diversifolium*

1. *E. pulchéllum* (Hedw.) Jenn. (*Hypnum pulchellum* Hedw.; *Hypnum strigosum* Hoff ; *Eurynchium strigosum* Br & Sch) Loosely cespitose, stoloniferous branches ascending; gradually attenuate, bright yellowish-green; scales ovate-lanceolate, concave, slightly plicate, costa four-fifths length and ending in a spine on the back; seta smooth, golden-brown, sporangium oblong-ovate, somewhat arcuate, inclined to horizontal; teeth confluent at the base, hyaline at the top Autumn. Soil, logs, and roots of trees in moist open woods. Lake, Clark.

2. *E. diversifólium* Br. & Sch. (*Hypnum diversifolium* Schimp) Denser, yellowish-green, branches not erect; scales dense, ovate, those of the branches obtuse. Fairfield.

6. BRYNHIA Kaurin

Loosely cespitose, dark green to yellowish or brownish: procumbent or stoloniferous, branches irregularly pinnate; scales loosely imbricated, concave, plicate, decurrent, serrate, costa single, ending near the middle of the scale; seta rough; sporangium cernuous, inclined to horizontal, gibbous dorsally, teeth confluent at the base, apically papillose, calyptra short and thick-rostrate.

1. Branch scales acute to short-acuminate, apex twisted .. *B. novae-angliae*
1. Branch scales long-acuminate; apex not twisted . . *B. graminicolor*

1. *B. nóvæ-angliæ* (Sull. & Lesq.) Grout. (*Hypnum novæ-angliæ* Sull. & Lesq.; *Brachythecium novæ-angliæ* Jaeg. & Sauer.) Bright green above, brownish-green below, branches ascending, distinctly julaceous; scales loosely imbricated when dry, erect-spreading when moist, ovate-lanceolate, maginus plane, ovate to ovate-lanceolate, dorsally papillose by projecting cell-angles, costa to the middle; perichaetial scales long-acuminate, ecostate, seta and sporangium dark reddish-brown; sporangium oblong, slightly arcuate. Winter. Soil and rocks in wet, shady places. Lake.

2. *B. graminícolor* (Brid.) Grout. (*Hypnum sullivantii* Spruce.) Loosely to densely cespitose, yellowish-green below, light green, branches erect, short; branch scales ovate-lanceolate, long-acuminate, reflexed below, sharply serrulate, perichaetial scales longer, faintly costate; seta glossy, sporangium reddish-brown, arcuate, inclined to horizontal, somewhat gibbous below, calyptra long-rostrate, curved upward. Winter. Moist shady soil and wet rocks. Clark, Fairfield.

7. OXYRYNCHIUM (Br. & Sch.) Warnst.

Loosely to densely cespitose, creeping, branches irregularly pinnate or fascicled, often complanate, scales non-plicate, only slightly concave, erect-spreading on branches, ovate, plane, serrulate, costa to the middle or beyond, often ending in a dorsal spine; seta rough, sporangium cernuous, inclined to horizontal, dorsally gibbous.

1. Aquatic, seta smooth .... *O. riparioides*
1. Terrestrial, seta rough .... *O. hians*

1. *O. riparioides* (Hedw.) Jenn. (*Hypnum riparioides* Hedw.; *Hypnum rusciforme* Neck.; *Eurynchium rusciforme* Milde.; *Rhynchostegium rusciforme* Br. & Sch.) Robust, loosely cespitose, dark, blackish below; primary stems creeping branches erect or ascending; scales ascending or erect-spreading, ovate to oblong, costa to beyond the middle of the scale, perichaetial scales ecostate, abruptly acuminate; seta castaneous, sporangium ovate to ovoid-oblong, inclined to horizontal, constricted below the mouth, lid obliquely rostrate. Early autumn. On dripping rocks or on stones in streams. "Ohio," by Lesquereux. No specimen in the herbarium.

2. *O. hians* (Hedw.) Jenn. (*Hypnum hians* Hedw.; *Eurynchium hians* Jaeg. & Sauer.; *Hypnum praelongum* Muell.; *Ptergynandrum apiculatum* Brid.) Loosely depressed-cespitose, light to yellowish-green, glossy; scales rather distant, erect-spreading, ovate, non-decurrent, blunt-acute to short-acuminate, often twisted, serrate, rough by thickened angles of the cells, costa ½-¾ length of the scale, ending in a dorsal spine; seta castaneous, sporangium arcuate, inclined to horizontal, oblong-cylindrical. Autumn. Champaign, Perry.

8. RHYNCHOSTÈGIUM Br. & Sch.

Cespitose, soft; creeping, irregularly pinnate scales dense, non-plicate, narrowed at the base; seta smooth.

1. *R. serrulàtum* (Hedw.) Jaeg. (*Hypnum serrulatum* Hedw.; *Eurynchium serrulatum* Lindb.) Loosely cespitose, bright green, lustrous when dry complanate; scales concave, ovate-lanceolate, costa to the middle, serrulate in the outer portion, apex often twisted, margin plane; seta ¾-1¼ in. long, glossy, sporangium castaneous, arcuate, oblong, constricted below the mouth when dry. Autumn. Soil, logs and roots of trees in moist shade. Clark, Lake.

12. *HYPNACEÆ.*

Various, cespitose, irregularly pinnate, often quite regularly pinnate; scales plurisrate, unistratose, erect-spreading or squarrose to imbricated, often secund or circinate, costa various, basal cells usually differentiated and mostly hyaline; seta elongated, sporangium usually arcuate, inclined to horizontal, peristome double, teeth usually confluent at the base, basal membrane of inner peristome high, segments keeled, calyptra obtuse to acute or short-rostrate.

1. Costa single to middle of scale or beyond.............................. 2
1. Costa double or none.. 6

2. Costa strong, percurrent or excurrent 3
2. Costa not reaching the apex 5
3. Paraphyllia numerous .... *Hygroamblystegium*
3. Paraphyllia few or none 4
4. Scales blunt and rounded at the apex, spreading or imbricated .... *Calliergon*
4. Scales acute to acuminate, secund .... *Drepanocladus*
5. Scales erect-spreading .... *Amblystegium*
5. Scales squarrose recurved .... *Campylium*
6. Stem and branch scales dissimilar, scales symmetric and at right angles to the stem 7
6. Stem and branch scales similar, often inserted obliquely on the stem and unsymmetric 12
7. Paraphyllia numerous, annual growth clearly defined .... *Hylocomnium*
7. Paraphyllia few or none 8
8. Stem scales somewhat squarrose-spreading to secund, acuminate 11
8. Stem scales imbricated, with tips somewhat spreading or secund 9
9. Rugose; scales narrowly lanceolate, acuminate, base broad; serrate at the apex .... *Rhytidium*
9. Scales broadly ovate or rounded, apex obtuse, faintly crenulate at the apex 10
10. Stems green; in swamps .... *Acrocladium*
10. Stems red; in dryer places .... *Hypnum*
11. Irregularly and distantly pinnate; scales squarrose .... *Rhytidiadelphus*
11. Closely pinnate; scales circinate-secund .... *Ctenidium*
12. Scales complanate; branches irregular 13
12. Scales not complanate; branches more regularly pinnate, often plumose .. 14
13. Scales decurrent, alar cells differentiated .... *Plagiothecium*
13. Scales not or little decurrent, alar cells little or not at all differentiated, *Isopterygium*
14. Scales falcate, circinate, or secund 15
14. Scales mostly spreading 16
15. Very irregularly pinnate; scales plicate; paraphyllia numerous .... *Ptilium*
15. Irregularly pinnate; scales scarcely or not at all plicate; paraphyllia few or none .... *Stereodon*
16. Scales strongly falcate-secund, obtuse or apiculate, alar cells distinctly differentiated; aquatic .... *Scorpidium*
16. Not secund; scales erect-spreading; not aquatic 17
17. Paraphyllia numerous; medium-sized mosses .... *Heterophyllon*
17. Paraphyllia lacking; small plants 18
18. Dull; scales lanceolate to linear-lanceolate; cells rhomboidal to elongate-hexagonal .... *Amblystegiella*
18. Shining; scales oval to oblong-lanceolate; cells narrow .... *Homomallium*

1. ISOPTERYGIUM Mitt.

Slender, cespitose, light or yellowish-green, glossy, irregularly-pinnately branched mostly; scales smooth, base narrow, margin plane, costa very short or none; seta smooth, sporangium actimorphic or weakly gibbous, rarely arcuate, bases of peristome teeth confluent, yellowish, apically hyaline; operculum conic, sometimes rostrate.

1. Scales entire or obscurely serrulate above 2
1. Scales distinctly serrulate at least in the outer half 3
2. Not complanate; two rows of cells at the base shorter and wider .. *I. pulchellum*
2. Complanate, basal cells hardly different .... *I. mullerianum*
3. Scales shortly bi-costate .... *I. geophyllum*
3. Scales ecostate or obscurely costate 4
4. Scales serrulate to the base .... *I. deplanatum*
4. Scales serrulate only in the outer half .... *I. turfaceum*

1. ***I. mullerianum*** (Schimp.) Lindb. (*Plagiothecium mullerianum* Schimp.; *Hypnum mullerianum* Hook. f.) Light green, yellowish,

laxly cespitose, branches often stoloniferous or flagelliform; scales ovate-lanceolate, concave, costa very faint, abruptly apiculate, pointing upward; seta castaneous, hypophysis elongated, sporangium erect to inclined, small, rare. Autumn. Rock crevices or soil in ravines. "Ohio," by Lesquereux. No specimen in the herbarium.

2 *I. deplanàtum* (Sull.) Mitt (*Hypnum deplanatum* Sull.; ***Rhynchostegium** deplanatum* Schimp) Bright green, glossy, flattened; scales dense, concave, ovate-lanceolate, thin; sporangium oblong-ovate, arcuate, cernuous, plicate when dry Autumn, fruit rarely found Clark.

3. *I. pulchéllum* (Dicks.) Jaeg. (*Hypnum pulchellum* Dicks.; *Plagiothecium pulchellum* Br & Sch.) Lustrous green, densely cespitose; stems prostrate, branches erect, crowded; scales crowded, sometimes secund, ovate-lanceolate, long, slender acuminate, ecostate, narrowed at the base; sporangium sub-erect to inclined Summer. Decayed wood, rocks and roots of trees. Champaign.

4. *I. turfàceum* Lindb. (*Hypnum turfaceum* Lindb ; *Plagiothecium turfaceum* Lindb.; *Stereodon turfaceum* Mitt.) Loosely cespitose, light to yellowish-green, prostrate with short branches; scales complanate, ovate-lanceolate, long-acuminate, basal cells wider and shorter; seta castaneous, sporangium oblong, oblique rostrate, slightly arcuate, plicate when empty, annulus large and double. Summer. Lake.

5. *I. geóphilum* (Aust.) Jaeg. (*Rhynchostegium geophilum* Aust.; *Phlagiothecium geophilum* Grout; *Hypnum depressum* Sull. & Lesq.) Loosely cespitose dark, glossy green, prostrate, irregularly branched; scales flat, rather distant, widely spreading, narrowed and rounded at the base, oblong-lanceolate, serrate in the outer half, apex rather blunt, a few basal cells sub-rectangular and hyaline: sporangium ovoid, inclined gibbous, operculum obliquely rostrate. Rare. Wet earth or stones near water in lowlands. Clark.

2. PLAGIOTHÈCIUM Br. & Sch.

Softly cespitose, larger than the preceding genus, bright to yellowish-green, lustrous, creeping to erect or ascending in thick mats, stoloniferous, branches often flagelliform; scales non-plicate, decurrent, ovate to lanceolate, acuminate, base narrowed, basal cells lax and hyaline; seta reddish, sporangium erect to cernuous, oblong to cylindrical, peristome yellowish, teeth confluent at the base.

1. Ascending, not distinctly complanate, spreading .... *P. roseanum*
1. Stems depressed, distinctly complanate 2
2. Costa strong, forked, often to the middle of the scale; sporangium striate when dry .. . . *P. sylvaticum*
2. Costa thin and short; sporangium usually smooth when dry....*P. denticulatum*

1. *P. sylváticum* (Huds.) Br. & Sch. (*Hypnum sylvaticum* Huds ; *H. denticulatum* C. Muell.) Softly cespitose, duller, olive or yellowish-green, prostrate, stoloniferous; scales concave, oval-lanceolate, decurrent, narrowed at the base, abruptly acute, plane, shrinking when dry so as not to overlap, perichaetial scales long-acuminate, non-costate; seta castaneous, slender, ¾–1½ in. long or more, sporangium yellowish,

arcuate, inclined, hypophysis elongated, striate, peristome orange below, pale above, lid conic, rostrate. Summer. Soil, rocks and wood in the woods. Fairfield, Franklin, Lake.

2. *P. denticulàtum* (L.) Br. & Sch. (*Hypnum denticulatum* L.) Flatly cespitose, pale green, lustrous, branches ascending; scales rather dense, sub-concave, little shrunken when dry, ovate-oblong, acute to short-acuminate, entire below, slightly denticulate near the apex, margin plane, widest at the base; seta 1–1¼ in., copper-colored, sporangium arcuate, cylindric, suberect to horizontal, hypophysis long, lid conic, peristome hyaline above. Summer. Logs, stones and humus in the woods. Ashtabula, Fairfield, Franklin, Hancock.

3. *P. roseànum* Br. & Sch. (*P. sullivantiæ* Schimp.; *Hypnum roseanum* Hampe.) Densely cespitose, yellowish-green, shining; sparingly branched; scales dense, ovate-oblong, short-acuminate, concave, serrulate near the apex, costa distinct; sporangium oblong-cylindrical, erect to inclined, lid oblique-rostrate, short. Summer. Stones and soil in swampy woods. Clark, Fairfield, Lake.

3. AMBLYSTÈGIUM Br. & Sch.

Cespitose, irregularly branched, branches more or less erect; scales erect-spreading to squarrose, acuminate, concave, non-plicate, costa thin to the middle or beyond; seta long, reddish or castaneous; sporangium arcuate, yellow or orange, constricted below the mouth when dry, lid conic.

1. Costa nearly percurrent to excurrent 2
1. Costa ending well below the apex, usually near the middle 4
2. Sharply and finely denticulate; median cells 6–10: 1; very slender, densely tufted .... *A. compactum*
2. Larger; obscurely denticulate or entire; median cells 3–6: 1 3
3. Scales ovate-acuminate, acute, slender acuminate .... *A. varium*
3. Scales ovate-cordate, abruptly and bluntly acuminate .... *A. orthocladon*
4. Slender, creeping; scales erect-spreading; median cells 2–6: 1 5
4. More robust, ascending; scales wide to squarrose-spreading; median cells 5–10 (15): 1 .... *A. riparium*
5. Median cells 2–4: 1 .... *A serpens*
5. Median cells 4–6 (8): 1 .... *A radicle*

1. *A. sèrpens* (L.) Br. & Sch. (*Hypnum serpens* L.) Very small and slender in thin compressed, dull mats, densely interwoven, prostrate, radiculose, irregularly branched; scales ovate-lanceolate, long-acuminate; serrulate to entire, decurrent, narrow at the base, plane, costa often faint; seta slender, ¾–1 in. long, sporangium strongly arcuate, lid apiculate, teeth pale. Early summer. Bases of trees, roots, long, soil, rocks, etc., in moist woods. Clark, Lake, Seneca.

2. *A. vàrium* (Hedw.) Lindb. (*Leskea varia* Hedw.; *Stereodon varius* Mitt.; *Hypnum debile* Brid.) Mats of varying density, dark green below, lighter above, prostrate, branches erect or ascending, irregular; scales rather dense; ovate-acuminate, entire or slightly denticulate, plane erect-spreading, decurrent, narrowed at the base, costa strong and well above the middle, basal cells larger and sometimes yellowish; seta ¾–1¼ in., castaneous, sporangium castaneous, strongly

arcuate. Spring. Stones, wood, bases of trees, etc., in moist places. Clark, Fairfield, Fulton, Lawrence, Logan, Montgomery.

3. *A. radicàle* (Beauv.) Mitt. (*A. serpens* var. *radicale* Aust.; *Hypnum radicale* Beauv.; *Hypnum bergense* Aust.; *Campylium radicale* Grout; *A. hygrophilum* (Jur.) Schimp.) Loose thin mats, pale-green, slender and little branched; scales distant, spreading, lanceolate to ovate-cordate, decurrent, slenderly acuminate, alar cells often enlarged and hyaline, costa orange; seta an inch or more in length, castaneous, sporangium yellowish, peristome teeth hyaline margined, sporangium castaneous. Spring. Rotten logs, roots, soil, in wet shady places Lake.

4. *A. orthocladon* (Beauv.) Jaeg. (*A. varium* var. *orthocladon* Husnot.; *Hypnum orthocladon* Beauv.) Dark to olive-green, compact, irregularly branched, branches erect; scales ovate-cordate, wide-spreading, base narrow, margins plane, serrulate, costa to the apex; seta castaneous, sporangium castaneous, arcuate, cernuous, constricted below the mouth when dry. Spring. Moist, shady stones, and rotten wood at the bases of trees. Clark, Fairfield, Franklin, Fulton, Lake, Logan, Montgomery.

5. *A. ripàrium* (L.) Br. & Sch. (*H. riparium* L.; *H. laxifolium* Brid.; *Stereodon riparium* Mitt.) Variable in loosely cespitose flat, soft tufts or floating in running water, creeping, sub-pinnate, ¾–1 in or more in length, 2–3 in. in floating forms, depressed; scales widely spreading, sometimes secund at tips, ovate-lanceolate to oblong-lanceolate, gradually and finely acuminate, flat, somewhat decurrent, rounded at the base, costa strong; sporangium oblong-cylindric, dark, lid apiculate. Spring. Clark, Champaign, Franklin, Lake.

6. *A. compàctum* (C. Muell.) Aust. (*Hypnum compactum* C. Muell.) Small, densely cespitose, light or yellowish-green, branches numerous; scales erect-spreading, lanceolate to ovate-lanceolate, long-acuminate, finely denticulate, seta short, sporangium erect or slightly inclined. Rotten logs or wet bases of trees. Champaign.

4. AMBLYSTEGIÈLLA Loesk.

Slender, filiform, creeping; scales erect-spreading or sometimes slightly secund, lanceolate to lance-subulate, margin plane, entire, costa faint or none; seta castaneous or reddish-yellow, sporangium usually erect and actinomorphic, constricted below the mouth when dry, peristome yellow, teeth confluent and bordered, cilia rarely complete.

1. Plants minute; scales not narrowed at the insertion........... *A. minutissima*
1. Plants larger; scales narrowed at the insertion..................... *A confervo*

1. *A. minutíssima* (Sull & Lesq.) Nichols. (*H. minutissimum* Sull. & Lesq.; *Amblystegium minutissimum* Jaeg.) Light green, prostrate, radicles fasciculate, branches erect or spreading; scales triangular, faintly serrate, ecostate; sporangium minute, ovoid, turbinate, when empty, lid conic, apiculate-rostrate. Rocks and stones in ravines. "Ohio," L. & J. Manual.

2. *A. confèrva* (Schweg.) Jenn. (*Hypnum confervoides* Brid.; *Amblystegium confervoides* Loesk.; *Hypnum conferva* Schweg.) Dark green, irregularly branched; scales rather distant, almost or quite entire, ovate, acuminate ecostate, somewhat appressed; sporangium arcuate, inclined, reddish-brown. Summer. Green, Clark.

5. HOMOMÀLLIUM (Schimp.) Loeske.

Shining, slender, creeping, pinnately branched with branches erect or ascending; scales erect-spreading, often secund at the tips, concave, non-plicate, ovate to oblong-lanceolate, long-subulate, plane, ecostate, or costa double, short and faint; seta reddish, sporangium inclined to horizontal, strongly arcuate when dry, constricted below the mouth, peristome yellow, teeth confluent basally, operculum short-rostrate.

1. *H. adnàtum* (Hedw.) Broth. (*Hypnum adnatum* Hedw.; *Amblystegiella adnata* Nichols; *Stereodon adnatum* Mitt.) Densely cespitose, light green above, darker below, branches close; scales dense, entire or nearly so, concave, recurved below; seta ½-¾ in. long, hypophysis long, sporangium reddish. Autumn. Clark, Franklin.

6. HYGOAMBLYSTÈGIUM Loeske.

Cespitose, dark green, dull, aquatic, often floating, pinnately branched; scales dense, spreading to secund, concave, non-plicate, ovate to lanceolate, long-acuminate, costa stout; seta castaneous, sporangium arcuate and constricted below the mouth when dry.

1. Scales entire or obscurely serrate, non-decurrent 2
1. Scales distinctly serrate, teeth small; mostly decurrent..... . *H. filicinum*
2. Scales sharply acute or acuminate ... . *H. tenax*
2. Scales obtuse, not acuminate.. ....*H. fluviatile*

1. *H. fluviàtile* (Swartz) Loeske. (*Amblystegium fluviatile* Br. & Sch.; *Hypnum fluviatile* Swartz.) Robust, gametophores to 4 in. long, olive or dark green, or blackish, naked below; scales oblong-lanceolate to oblong-ovate, remote, erect-spreading, concave, recurved at base, costa percurrent, yellowish, basal cells often yellowish or orange; seta about ½ in. long, sporangium oblong-cylindrical, sub-erect, yellowish, brown, slightly curved; teeth strongly confluent at the base, hyaline and papillose at the apex, cilia nodose, three. Early summer. Earth and stones near running water in non-calcareous districts. Clark, Fairfield.

2. *H. tenax* (Hedw.) Jenn. (*H. irriguum* Loeske; *Hypnum irriguum* Wils.; *Amblystegium irriguum* Br. & Sch.; *Hypnum tenax* Hedw.) Cespitose, dark green, rigid, irregularly branched, pinnate, with long paraphyllia at the insertion of the branches; scales deltoid-ovate-lanceolate, gradually long-acuminate, somewhat narrowed at the base and slightly decurrent, spreading, somewhat secund at the tips, cost percurrent, basal cells enlarged, yellowish; seta ½ in. long, sporangium brown, oblong, lid apiculate, peristome orange, pellucid. Late spring and early summer. Earth or stones in swampy places in non-calcareous regions. Greene, Wyandot.

3. *H. filicinum* (L.) Loeske. (*Amblystegium filicinum* DeNot.; *Stereodon filicinus* Mitt.; *Hypnum filicinum* L.; *Cratoneuron filicinum* G. Roth; *Hypnum compressum* Brid.) Variable, tufted, 2–4 in. deep, bright to yellowish-green, brown below, densely tomentose, paraphyllia laciniate, quite regularly pinnate; scales cordate-deltoid, gradually slender-acuminate, erect-spreading, secund at the tips of the gametophores, non-plicate; costa percurrent, alar cells inflated, hyaline or colored, auricled; seta 1–1½ in. long, sporangium sub-cylindric. Spring. On earth or stones in springs or streams in limestone regions. Champaign, Lake.

7. DREPHANOCLÀDUS (C. Muell.) Roth.

Robust, usually glossy, stems procumbent to erect or floating; scales strongly secund, concave, decurrent, acute to long-acuminate, costa thin, usually single, smooth, basal cells hyaline or yellowish, well-defined; seta long, sporangium cylindric, arcuate, constricted below the mouth when dry, lid apiculate.

1.	Alar cells not inflated or decurrent, but thicker and broader, scales entire	*D. revolvens*
1.	Alar cells distinctly enlarged and inflated, often either decurrent or serrate or both	2
2.	Scales entire, alar cells greatly enlarged	4
2.	Some or all scales plainly dentate	3
3.	Scales plicate	*D. uncinatus*
3.	Scales not plicate	*D. fluitans*
4.	Acumen flat, scarcely or not at all hooked	*D. kneifii*
4.	Acumen channeled, tips hooked	5
5.	Gradually long-acuminate	*D. aduncus*
5.	Abruptly short-acuminate	*D. aduncus* var. *gracilescens*

1. *D. uncinàtus* (Hedw.) Warnst. (*Hypnum uncinatus* Hedw.; *Amblystegium aduncum* Lindb.; *Hypnum aduncum* L.) Densely cespitose, light to golden-green, irregularly pinnate; scales dense, falcate to circinate, lanceolate, acuminate long, dentate above, costa into the acumen, strongly plicate, basal cells only slightly enlarged and inflated; seta 1 in. or more long, copper colored, sporangium reddish-orange, arcuate. Early summer. Earth, stones, logs and bases of trees in moist shady places. Champaign, Clinton, Fairfield, Franklin, Lake.

2. *D. revólvens* DeNot. (*Hypnum revolvens* Sw.) More robust, 2–3 in. deep, loosely tufted, yellowish or light green above, dark reddish-purple below; scales linear-lanceolate, long slender-acuminate, costa to above the middle; sporangium erect, cernuous, oblong-ovoid, scarcely constricted below the mouth when dry. In wet soil. Reported from the swamps of northern Ohio by Lesquereux.

3. *D. adúncus* (Hedw.) Warnst. (*Hypnum aduncus* Hedw.; *Amblystegium watsonii* (Sch.) Lindb.) Slender and soft, green or golden green, darker below; scales rather distant, moderately hooked at the tip of branch, wide cordate at base, strongly excavate, forming a complete semicircle between the auricles, costa to about ¾ the length of the scale, lanceolate, often twisted, basal cells abruptly inflated; the scale, seta 1 in. or more long, sporangium oblong, arcuate, inclined. Wet soil and stones or floating in deep pools. Champaign, Lake.

4. *D. aduncus* var *gracilescens* Br. & Sch. (*D. subaduncus* Warnst) Sparingly branched, branches short and erect, yellowish-green; scales ovate to ovate-lanceolate, base less deeply and widely excavate than in the species. Late spring. Swamps and wet places. Fruit rare. Lake.

5. *D. kneifii* (Schimp.) Warnst. (*Hypnum aduncum* var. *kneifii* Schimp.; *Amblystegium kneifii* Br. & Sch.) Branches slender, long and flexuous; little hooked at the tips; scales distant, narrow lanceolate, upper one wider and shorter, alar cells inflated, and extending to the costa. Late spring. Fruit rare. In water in swamps and streams. Not reported.

6. *D. fluitans* (L.) Warnst (*Amblystegium fluitans* DeNot.; *Hypnum fluitans* L.) Soft tufts, 2-3 in. deep, irregularly pinnate, erect, light or yellowish-green above, brown below; scales secund, narrow or oblong-lanceolate, very long acuminate, non-plicate, costa extending into the acumen or percurrent, denticulate, not deeply excavate; seta 1 in. or more, copper-colored, sporangium arcuate, reddish-orange, annulus none. Summer In water in swamps and streams. Clark.

8. CALLIÉRGON (Sull.) Lindb.

Robust, erect; scales not falcate or secund obtuse, broadly oblong-ovate to almost orbicular, concave, costa simple and strong or wanting; sporangium arcuate, inclined to horizontal, peristome hypnoid.

1. Scales imbricate when dry; almost simple mosses 2
1. Scales erect-spreading or loosely imbricated; branched . 3
2. Scales almost round, very obtuse; auricles indistinct . . . . . *C. trifarium*
2. Scales oblong, auricles distinct . . . . *C. stramineum*
3. Sparingly branched, alar cells gradually passing to the ordinary cells, *C. cordifolium*
3 Much branched; alar cells abruptly differentiated from the ordinary cells . . . . *C. giganteum*

1. *C. cordifólium* (Hedw) Lindb. (*Hypnum cordifolium* Hedw.; *Amblystegium cordifolium* DeNot.) Large mosses, 4-6 in. tall, light green, loose tufts, stalks erect, slender; scales distant, widely spreading, ovate-cordate, entire, decurrent; seta to 2 in. long, castaneous, sporangium golden-brown. Summer. Swamps or margins of pools or sluggish streams. Lake.

2. *C. gigánteum* (Schimp.) Lindb. (*Hypnum giganteum* Schimp.; *Amblystegium giganteum* DeNot.) Very robust, 3-6 in. tall, loosely tufted, stalks thick, pinnately branched, bright green, brown below; scales oblong, alar cells hyaline; seta castaneous, 2 in. or more long, sporangium distinctly arcuate, brown. Late spring and early summer. Swamps and bogs. Champaign.

3. *C. stramíneum* (Dicks.) Lindb. (*Hypnum stramineum* Dicks.; *Amblystegium stramineum* DeNot.) Pale green, loose tufts, 2½-3 in. deep, stems erect and slender; scales oblong-ovate to oblong, costa to beyond the middle, alar cells hyaline, forming distinct decurrent auricles, a patch of shorter cells in the apex; sporangium oblong-cylindrical. Summer. In bogs, often among sphagnum. Erie.

4. *C. trifàrium* (Web. & Mohr.) Kindb. (*Hypnum trifarium* Web. & Mohr.; *Amblystegium trifarium* DeNot.) Robust, golden or dirty green above, brown below, tufts loose, prostrate to erect, stiff and brittle when dry; scales loosely imbricated, ovate, wide slightly decurrent, entire, wide near the middle, alar cells enlarged and hyaline; sporangium cernuous, horizontal, reddish. Bogs and pools. Erie.

9. SCORPÌDIUM (Schimp.) Limpr.

Very robust, sparingly branched, branches fastigate; scales strongly secund, imbricate, turgid, broad-ovate, costa indistinct or none.

1. *S. scorpioìdes* (L.) Limpr. (*Hypnum scorpioides* L.; *Amblystegium scorpioides* Lindb.) Soft tufts, brownish-green, above, almost black below, branches erect or ascending, almost simple, 4–6 in. long; scales very concave, imbricated, rugose, non-plicate, ovate-oblong, narrowed at the base, entire, costa very short and double, obtuse or apiculate, a few basal cells wider and hyaline; seta long, sporangium arcuate, not constricted below the mouth when dry. Late summer. Bogs and marshes in the water. Champaign. "Cranberry marshes of northern Ohio," Lesq

10. CAMPYLIUM (Sull.) Mitt. (*Chrysohypnum* [Hampe.] G. Roth.)

Soft thin mats; scales ovate-acuminate, acute, widely spreading, squarrose, or secund not falcate; sporangium arcuate, usually contracted below the mouth when dry, lid conic-convex, peristome hypnoid.

1. Costa single, distinct, half the length of the scale............*C. chrysohypnum*
1. Costa short and double or wanting.. 2
2. Stems prostrate; scales serrulate..............................*C. hispidulum*
2. Stems erect or ascending; scales entire.........................*C. stellatum*

1. *C. hispìdulum* (Brid.) Mitt. (*Hypnum hispidulum* Brid.) Thin tufts, small, slender, creeping, bright green, irregularly branched; scales widely spreading to squarrose, triangular-cordate, abruptly acuminate, decurrent; seta copper-colored, 1 in. long, sporangium light, much curved, mouth wide. Early summer. Wood, humus and roots of trees in moist woods. Champaign, Clark, Fairfield, Franklin, Fulton, Geauga, Lake, Lawrence, Richland.

2. *C. chrysophyllum* (Brid.) Bryhn. (*Hypnum chrysophyllum* Brid.; *Hypnum polymorphum* Br. & Sch.) Thin, delicate, loose mats, bright or yellowish-green, creeping, irregularly branched; scales squarrose-spreading, base narrowed, somewhat clasping, occasionally secund, ovate-cordate, abruptly acuminate; seta copper-colored, sporangium much curved, peristome light. Early summer. Earth, wood and stones in moist places. Champaign, Clark, Fairfield, Greene, Montgomery, Pickaway, Seneca, Lake.

3. *C. stellàtum* (Schreb.) Bryhn. (*Hypnum stellatum* Schreb.; *Amblystegium stellatum* Lindb.) Robust, 2–4 in. tall, variable in appearance, soft tufts, bright green, brown below; scales squarrose or recurved, bistriate at base, alar cells inflated, hyaline or colored, base ovate or cordate, rather abruptly acuminate; seta brown, sporangium

dark reddish-brown, cernuous, constricted below the mouth when dry, teeth orange at the base, lighter above. Summer. Swamps, in water or on wet soil. Champaign.

11. CTENÍDIUM (Schimp.) Mitt.

Loosely cespitose, densely bi-pinnately branched, plumose; scales long-acuminate, circinate, secund, costa short and double, sporangium sub-horizontal, curved, thick-ovate, lid conical-apiculate.

1. *C. mollúscum* (Hedw.) Mitt. (*Hypnum molluscum* Hedw.) Wide soft mats, yellowish-green, stems to 3 in. long, prostrate, or ascending; scales cordate-triangular, auricled round, quadrate cells not much enlarged, pellucid crisped when dry, plane, serrate, decurrent, more or less rough by the projecting angles of the cells, paraphyllia few. Summer. Earth or stones in limestone regions. Champaign, Lake.

12. PTÍLIUM (Sull.) DeNot.

Robust in deep loose tufts, frondiform, stems rigid, closely and regularly pinnately branched; scales sulcate, seta long and slender. falcate, secund; sporangium arcuate to horizontal, oblong-cylindric.

1. *P. crísta-castrénsis* (L.) DeNot. (*Hypnum crista-castrensis* L.) Bright, yellowish-green, darker below, 2–5 in. deep, strikingly plumose, branches horizontally divergent, about equal in length except at the tips; paraphyllia numerous; scales plicate, crowded, serrate in the outer part, alar cells enlarged, hyaline, decurrent, costa short and double or wanting; seta reddish-brown, sporangium lighter, 1-1½ in. long, lid large, teeth orange at the base. Summer Earth or rotten logs in wet woods. "Northern Ohio," H. C. Beardsley.

13. HYLOCÓMNIUM Br. & Sch.

Robust, loosely cespitose, paraphyllia abundant in our species, annual growth well marked, plumose, tripinnate, or bipinnate; scales occasionally papillose on the back by projecting angles, basal cells often colored; sporangium curved, inclined to horizontal, peristome hypnoid.

1. Regularly bi- or tri-pinnate; stem scales gradually acuminate, not auricled, *H. splendens*
1. Irregularly pinnate; stem scales abruptly acuminate; auricled. . *H. brevirostre*

1. ***H. brevirόstre*** (Ehrh.) Br. & Sch. (***Hypnum brevirostre*** Ehrh.) Tufts large, 3–5 in. deep, coarse, rather rigid, paraphyllia small; stem scales spreading, squarrose, or sub-secund, obcordate-ovate to cordate-triangular, faintly bi-costate, serrulate above, auricles rounded; sporangium arcuate, turgid-oblong, ovate, lid acuminate, sub-rostrate, or long conical, teeth orange. Spring. Rocks and bases of trees in wet ravines. Lake.

2. ***H. spléndens*** (Hedw.) Br. & Sch. (***Hypnum proliferum*** L.; ***Hylocomnium proliferum*** Lindb.; ***Hypnum splendens*** Hedw.) Loose rigid tufts pale green above, darker below, paraphyllia branched, annual growth arcuate; stem scales wide-ovate to oblong-ovate, rather

abruptly acuminate, acumen long, plicate, concave, basal cells orange, costa obscure, double; sporangium turgid-ovate, lid rostrate. Spring. Log and stones in moist woods Cuyahoga.

14. HYPNUM (Dill.) L.

Robust, prostrate to ascending, irregularly pinnate; scales loosely imbricated, costa double and short or none, obtuse, deeply concave; sporangium oblong, arcuate, lid conic-convex.

1. *H. schrĕberi* Wild. (*Hylocomnium schreberi* DeNot.; *Hypnum parietum* L.; *Hylocomnium parietum* Lindb.) Densely cespitose, cushions 2–5 in. deep, pale grayish-green or olive green, glossy, older stems bright red; scales ovate to oblong, dense, obtuse, incurved at the apex, plicate, entire or slightly crenulate in outer portion, alar cells enlarged, hyaline or colored; sporangium inclined, reddish, annulus none, seta purple. Fruit rare Autumn. Dry open woods, banks, etc. Champaign, Lake.

15. RHYTÍDIUM (Sull.) Lindb.

Robust, non-radiculose, irregularly pinnate, paraphyllia lacking; scales plicate, costa simple to beyond the middle, calyptra large, lid rostrate, annulus broad

1. *R. rugósum* (Ehrh.) Lindb. (*Hypnum rugosum* Ehrh.; *Hylocomnium rugosum* DeNot.) Large, 2–4 in deep, dense mats, bright yellowish-green, glossy, tumid; scales strongly secund, papillose on back, transversely undulate-rugose, revolute, denticulate, alar cells numerous, quadrate; sporangium oblong-cylindric, deeply arcuate, constricted below the mouth when dry. Fruit rare. Summer. Dry banks among the grass and on ledges. Greene, Lake

16. RHYTIDIADÉLPHUS (Lindb.) Warnst.

Robust, irregularly and distantly bi- or tri-pinnate; scales squarrose or spreading-secund, paraphyllia lacking; sporangium turgid, ovate.

1. *T. triquĕtris* (L.) Warnst. (*Hypnum triquetrum* L.; *Hylocomnium triquetrum* Br. & Sch.) Very robust, wide tufts, 4–6 in. deep, yellowish to light green, stems stiff, reddish, erect or ascending, branches unequal, not complanate; scales widely spreading deltoid to broadly ovate, stiff, rarely secund, gradually tapering, acute, plicate, denticulate, papillose on the back; seta 1–1½ in. long, sporangium oblong, lid conic-acute, teeth orange with a yellow border. Spring. Soil in swampy or dry woods. Champaign, Fairfield, Lake.

17. ACROCLÀDIUM Mitt.

Robust mosses, loosely tufted, irregularly pinnate; scales spreading, costa double and very short or ecostate, entire, obtuse; sporangium oblong, arcuate.

1. *A. cuspidàtum* (L.) Lindb. (*Hypnum cuspidatum* L.; *Stereodon cuspitatus* Brid.) Bright or yellowish-green, glossy, branches cuspidate at the tips; lower scales erect-spreading, oblong-elliptical, rounded at the

apex, alar cells suddenly enlarged, hyaline or colored, auricles large and decurrent; seta 1½–2½ in. long; sporangium strongly arcuate, golden-brown, teeth hyaline-bordered. Summer. Wet meadows, swamps and bogs. Summit.

18. STÊREODON (Brid.) Mitt.

Pinnately branched, more or less regularly; scales falcate-secund, smooth, acuminate, costa double or wanting; sporangium usually curved, sub-erect to inclined, lid short-rostrate.

1.	Alar cells inflated, hyaline or colored	2
1.	Alar cells quadrate, not enlarged	7
2.	Quite distinctly pinnate	3
2.	Not distinctly pinnate	6
3.	Sporangium sub-erect; stems reddish	4
3.	Sporangium curved or inclined; stems not reddish	5
4.	Robust, closely pinnate, more or less complanate	*S. impones*
4.	Slender, branches few, not complanate	*S. tenuirostris*
5.	Small yellowish; sporangium non-plicate	*S fertile*
5.	Larger, dark green; sporangium plicate when dry	*S. curvifolium*
6.	Scales entire; alar cells rather few	*S. pratense*
6.	Scales sharply serrate above; alar cells conspicuous	*S. recurvans*
7.	Scales entire; not regularly pinnate	*S. cupressiformis*
7.	Scales serrulate, at least above; regularly pinnate	*S. reptilis*

1. *S. rêptilis* (Rich.) Mitt. (*Hypnum reptilis* Rich.) Small, dark or yellowish-green, loosely cespitose: scales dense, lanceolate-acuminate serrate above, usually serrulate below, lower margins revolute, alar cells quadrate, somewhat colored, costa yellowish when present; seta about ½ in. long, sporangium yellowish, curved near the mouth and narrowed, lid oblique-rostrate. Summer. Bases of trees, logs, etc., in woods. Clark.

2. *S. fêrtilis* (Sendt.) Lindb. (*Hypnum fertile* Sendt.) Lustrous, densely cespitose, prostrate or ascending to 3 in. long, branches sparse, short; scales oblong-lanceolate, long and narrowly acuminate, concave, plane, entire below, serrulate above, narrowed at the base, a few alar cells inflated at the margin; seta ½–¾ in., castaneous, sporangium inclined to horizontal, oblong, arcuate, castaneous, rim darker, somewhat constricted below the mouth when dry, lid conic, acute Wood decaying in moist places. Champaign.

3. *S. impônens* (Hedw.) Lindb (*Hypnum imponens* Hedw.) Wide, densely interwoven, yellowish mats, stems prostrate, closely pinnate, forming flat fronds, paraphyllia numerous; scales ovate at base, gradually long-acuminate, strongly falcate-secund, somewhat complanate, margin usually recurved below, alar cells quadrate with a few inflated and orange pellucid in angles, auricled; seta slender, castaneous, 1–1½ in. long, sporangium reddish-brown, slightly curved, nearly erect, lid long-rostrate, acuminate. Autumn or early winter. Stones, soil or wood in moist woods. Clark, Fairfield, Franklin, Greene, Lake, Lawrence, Licking.

4. *S. cupressifôrmis* (L.) Lindb. (*Hypnum cupressiformis* L.) Wide, densely-interwoven mats, yellowish to brownish-green, variable in size, paraphyllia less numerous than in the preceding species, more

irregularly pinnate, prostrate; scales dense, imbricated, concave, oblong to ovate, abruptly acuminate, entire below, serrulate above, subulate, alar cells few, clear, usually hyaline; sporangium curved, oblong-constricted below the mouth when dry, lid acuminate. Late autumn or early winter. Earth, stones, roots of trees in moist woods. Lake, Seneca.

5. *S. cupressiformis* var. *ericetòrum* (Br. & Sch.) (***Hypnum cupressiforme*** var. ***ericetorum*** Br. & Sch.) Soft, pale green, lustrous; scales less dense than in the species, narrow and more widely spreading, circinate-falcate; sporangium shorter, lid short-subulate. Perry.

6. *S. cupressiformis* var. *filifórmis* (Brid.) Jenn. (*Hypnum cupressiformis* var. *filiformis* Brid.) Slender, distantly pinnate, branches long, slender and parallel, mats thin; scales in two rows, imbricated. On soil rocks and rotten wood in moist woods. Franklin.

7. *S. curvifòlius* (Hedw.) Brid. (*Hypnum curvifolium* Hedw.) Wide, flat, yellowish-green mats, branches short and unequal, closely pinnate, prostrate; scales in two rows, falcate-secund, appearing plaited from above, entire or serrulate in the outer part, concave, oblong-ovate to long-triangular-ovate, slightly decurrent with enlarged and hyaline cells, alar cells sub-quadrate; seta 1–1½ in. long, castaneous, sporangium light castaneous, constricted below the mouth when dry, arcuate, cernuous, teeth yellow-pellucid, lid conic-apiculate. Spring. Decaying logs, and rocks in cool moist woods. Champaign, Clark, Fairfield, Lake, Williams.

8. *S. pratènse* (Koch.) Warnst. (*Hypnum pratense* Koch.; *Isopterygium pratense* Lindb.) Flatly cespitose, complanately branched, bright green; scales slightly concave or plane, only slightly secund, alar cells colored, few; sporangium non-plicate, ovate to oblong, cernuous, arcuate, seta twisted in two directions, fruit rare. Spring. Wet or swampy soil. Franklin.

9. *S. recùrvans* (Rich.) Broth. (*Hypnum recurvans* Schwaeg.; *Sematophyllum recurvans* E. G. Britt.; *Leskea recurvans* Rich.; *Raphidostegium recurvans* Jaeg.) Widely cespitose, yellowish green, glossy, complanately branched; scales strongly falcate-secund, dense, imbricated, concave, ovate-lanceolate, filiform-acuminate, narrowly recurved below, basal cells yellow, a few alar cells hyaline; seta ½–1 in. long, sporangium oblong-ovate, inclined, slightly arcuate, strongly so when old; lid conic, beak oblique, ½ the length of the sporangium, neck tapering. Late fall. Wood and soil at the base of trees. Fairfield, Lake.

10. *S. tenuiróstris* (Br. & Sch.) Broth. (*Sematophyllum tenuirostris* E. G. Britt.; *Hypnum cylindrocarpum* C. Muell.; *Raphidiostegium cylindrocarpum* Jaeg.) Flatly cespitose, dense, in wide mats, branches, sparse; scales oblong-lanceolate, narrow, slenderly acuminate, margins recurved, concave; seta ½–¾ in. long, sporangium cylindric, almost or quite erect, brownish, peristome yellow, cilia rudimentary or wanting, lid with an oblique rostrum about one-half the length of the sporangium. Winter. Rotten logs and rocks, usually in hilly or mountainous regions. Champaign, Clark.

19. HETEROPHYLLON Lindb.

Various, paraphyllia large and numerous; scales erect-spreading, non-plicate, basal cells yellow, alar cells inflated, yellow or brownish, sharply differentiated, not falcate or secund.

1. ***H. haldanianum*** (Grev.) Lindb. (***Hypnum haldanianum*** Grev.; ***Stereodon haldanianum*** Lindb.) Loose mats, brownish-green, irregularly pinnate scales loosely imbricated, stem scales broad, lance-ovate, short acuminate, auricles distinct and concave, bordered by quadrate cells; seta 1½–2 in. long, castaneous, sporangium cylindrical inclined or sub-erect, slightly curved, lid short and sharp rostrate. Autumn and early winter. Earth, rocks, and decaying wood in woods. Fairfield, Lake, Perry.

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PRINCIPLES OF PLANT TAXONOMY, X*.

JOHN H. SCHAFFNER.

In previous papers the remarkable fact has been presented that the entire plant kingdom as it exists today is made up of seven progressive stages or subkingdoms with definite transition gaps of greater or less extent between them. The whole series is the result of a building up process, the higher emerging from the lower throughout the entire system. The gaps do not represent breaks in the evolutionary progression but simply the aquisition of new potentialities with a greater or less elimination of groups of plants in the transition condition from one cause or another. In some cases the geological record has supplied important missing links in others no definite transition types whatever have so far been uncovered.

In some quarters, there has been a tendency to use these breaks in the general continuity in support of fantastic evolutionary theories which would give new starting points for the various isolated groups practically all along the geological history. The fact of the non-conformity in the geological formations is supposed by some to give plausibility to the notion that there were many independent transitions from the non-living to the living. Such notions are not only fantastic but greatly increase the difficulties they would remove.

It is just in those regions of the general progressive series where the evolutionary movement compels a decided change in external life relations that the great breaks occur. Of the six transitions within the present taxonomic system of plants two, the first and the fourth, present no very great hiatus even though the new potentialities added are very effective in determining new modes of biological reactions and processes.

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At the appearance of sex, with the initiation of fertilization and reduction, a profound change is brought about in the method of hereditary transmission, namely Mendelian heredity, which is added to the previous mode of purely nonsexual propagation. In the fourth transition, where the time of sex determination is shifted to the sporophyte, and new biological relations are established, including decided sex dimorphisms and dimorphic reactions in various parts of the bisporangiate or monecious individual, there is also only a slight break in the continuity of forms in the various phyla which pass through this change. On the other hand, the remaining transitions involved readjustments to ecological relations and here the destruction of forms, judging from the size of the gaps, has been very great.

The great transition from the Thallophyta to the Metathallophyta involves the passage from aquatic life to a properly adjusted aerial life and also the establishment of one generation as a parasite on the other. In the transition to the vascular plants the ecological change involved is from a completely parasitic condition to a two-phased condition of the sporophyte, the parasitic juvenile phase of the individual changing gradually to an independent mature phase which finally evolves roots and prominent leaves. In the transition to the seed condition the ecological changes are again very great involving the complete parasitism of the gametophyte on the mature sporophyte, the establishment of a two-phased male gametophyte, and the intercalation of a resting phase between the parasitic and independent phases of the sporophyte. This necessitates the acquirement of very rapid readjustment reactions during the sprouting period, along with numerous other minor changes. It is no wonder that plants evolving through this progression were destroyed by the wholesale as they encountered the oscillating changes of climate and earth level during the geological ages. The transition of both the Gymnosperms and Angiosperms was from a Heterosporous Pteridophyte condition. The transition to the Angiosperms is not, properly speaking, a transition from Gymnosperms to Angiosperms but only a transition of a much greater extent and much greater advance from lower forms than that which took place in relation to the Gymnosperms. The most important change, involving ecological readjustment, was the closing of the megasporophyll, making necessary a new organ, the stigma, for the process of pollination. The closing of the sporophyll is in evidence in various degrees in some Ferns, but in these there was no serious ecological relation involved as in the Angiosperms. In the Angiosperms not only must pollination be accomplished through a new organ, as compared with the gymnospermous condition, but the pollen tube must be readjusted to a new ecological relation, commonly involving growth through an open cavity, and, of course, growth of a much greater extent than is necessary in the Gymnosperms. These new ecological relations are probably largely responsible for the great hiatus separating our present day Angiospermæ from their nearest possible, living relatives, the Eusporangiate Ferns.

Any careful study of the taxonomic system, immediately emphasizes the remarkable fact of the great similarity and uniformity running through the whole extent of both the plant and animal series and the remarkable similarity of fundamental characteristics and properties possessed in common by the highest forms in contrast to their dissimilarity to the lowest organisms, like the lower Blue-green Algæ and Bacteria. Taking an inventory of the more important similarities exhibited by the highest plants and the highest animals, we get the following:

1. They both have essentially similar cell organization.
2. They both have the same general type of cell division (karyokinesis).
3. They both begin life as single cells.
4. They both develop into enormous, multicellular aggregates
5. They both have differentiation systems of cells, tissues, and organs.
6. They both have sex potentiality.
7. They both have primary sexual states, causing attraction.
8. They both have essentially similar dimorphic gametes, or heterogamy.
9. They both have secondary sexual states with secondary sexual dimorphism.
10. They both produce a unitary reproductive cell from two independent units (fertilization), thus developing as diploid organisms.
11. They both have a synapsis of homologous chromosomes, resulting in a definite segregation (reduction division).
12. In consequence of fertilization and reduction, they both show fundamentally similar hereditary phenomena, namely Mendelian heredity, involving the phenomena of dominance and recessiveness and proportionate segregation of characters after hybridization.

13. They both show a general adaptation to an aerial life and dry land habitat while at the same time betraying vestigial characters indicating an evolution out of an aquatic condition.
14. They both have a parasitic interrelation of offspring to parent, the offspring developing within the protective confines of the parent.
15. They both have sperm cells which are not deposited into the water, as in lower sexual forms, but into the ovary or a special cavity of the female.
16. They both provide a food supply in one way or another to assist the offspring in establishing an independent life after the parasitic connection is broken.
17. In both the higher animals and plants there is a very decided and abrupt change from the parasitic connection to the independent life, the embryonic individual very quickly developing entirely new reactions and functions not in evidence before.
18. In the unisexual species, they both show a greater or less supply of vestigial structures of the opposite sex, indicating an evolution from a former hermaphroditic condition and the same mode of determinate orthogenetic evolution of the time of sex determination in the life cycle.
19. They both show definite correlation reactions throughout the organism as a whole together with the development of definite functional gradients.
20. They both show stability in the more fundamental group characteristics and frequently instability in small specific differences.

This array of similarities and others that might be enumerated show that the entire organic kingdom is a unit and has had a common starting point and an essentially similar mode of evolution. The lowest organisms known lack all of the things given above with the exception of a partial realization of the first characteristic and a slight evidence of the last one. As stated, since we have these profound biological parallelisms between such extreme phylogenetic lines as the highest plants and the highest animals we are impelled to accept the view of a single common origin if we are to maintain an evolutionary principle on a basis of logic and common sense rather than on a foundation of anarchistic reasoning.

The great hiatuses are then to be interpreted as breaks in the survival series rather than as breaks in the uniform continuity of the organic evolutionary process; and we may then proceed to fill out the great gaps as best we can with theoretical and fossil forms.

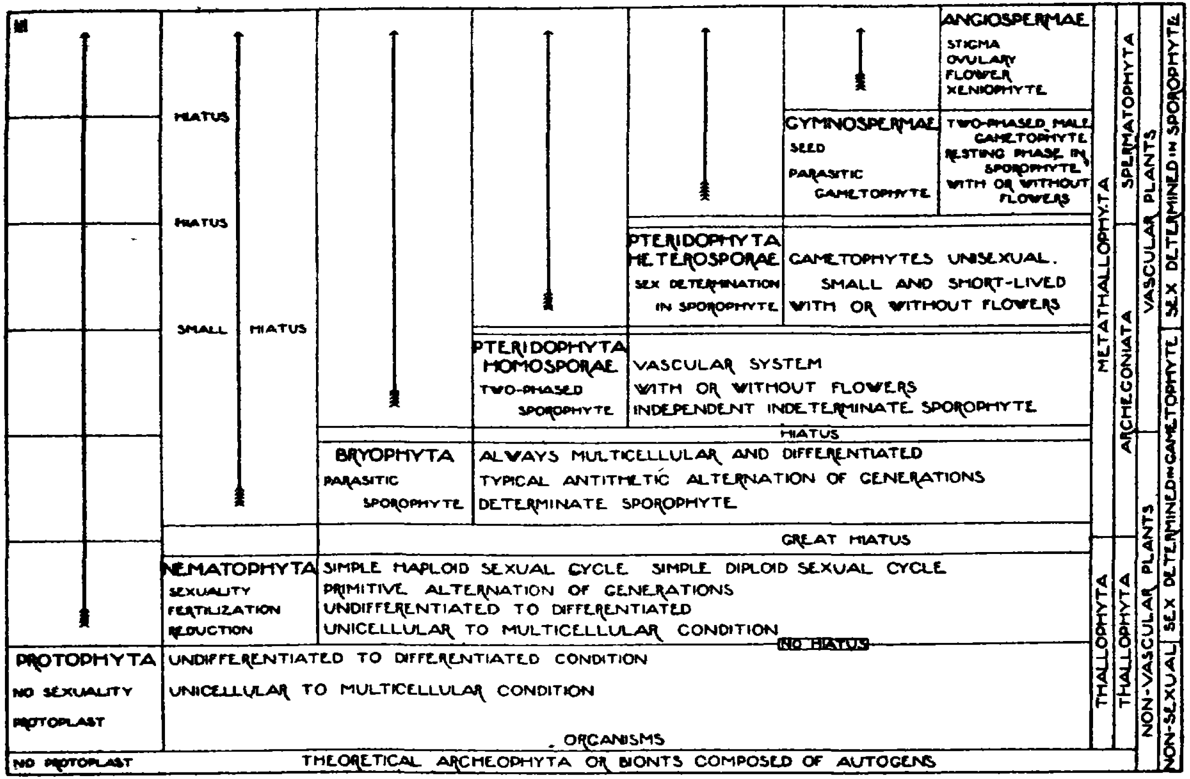
III
ANGIOSPERMAE
STIGMA
OVULARY
FLOWER
XENIOPHYTE
GYMNOSPERMAE
SEED
PARASITIC GAMETOPHYTE
TWO-PHASED MALE GAMETOPHYTE
RESTING PHASE IN SPOROPHYTE
WITH OR WITHOUT FLOWERS
PTERIDOPHYTA HETEROSPORAE
SEX DETERMINATION IN SPOROPHYTE
GAMETOPHYTES UNISEXUAL.
SMALL AND SHORT-LIVED
WITH OR WITHOUT FLOWERS
PTERIDOPHYTA HOMOSPORAE
TWO-PHASED SPOROPHYTE
VASCULAR SYSTEM
WITH OR WITHOUT FLOWERS
INDEPENDENT INDETERMINATE SPOROPHYTE
HIATUS
BRYOPHYTA
PARASITIC SPOROPHYTE
ALWAYS MULTICELLULAR AND DIFFERENTIATED
TYPICAL ANTITHETIC ALTERNATION OF GENERATIONS
DETERMINATE SPOROPHYTE
GREAT HIATUS
NEMATOPHYTA
SEXUALITY
FERTILIZATION
REDUCTION
SIMPLE HAPLOID SEXUAL CYCLE SIMPLE DIPLOID SEXUAL CYCLE
PRIMITIVE ALTERNATION OF GENERATIONS
UNDIFFERENTIATED TO DIFFERENTIATED
UNICELLULAR TO MULTICELLULAR CONDITION
NO HIATUS
PROTOPHYTA
NO SEXUALITY
PROTOPLAST
UNDIFFERENTIATED TO DIFFERENTIATED CONDITION
UNICELLULAR TO MULTICELLULAR CONDITION
ORGANISMS
NO PROTOPLAST
THEORETICAL ARCHEOPHYTA OR BIONTS COMPOSED OF AUTOGENS
HIATUS
HIATUS
SMALL HIATUS
METATHALLOPHYTA
THALLOPHYTA
SPERMATOPHYTA
ARCHEGONIATA
THALLOPHYTA
VASCULAR PLANTS
NON-VASCULAR PLANTS
SEX DETERMINED IN SPOROPHYTE
SEX DETERMINED IN GAMETOPHYTE
NON-SEXUAL

Chart showing the seven fundamental divisions or subkingdoms of living plants and the way the fundamental system is built up by the addition of potentialities to those already present.

THE TRANSITION FROM THE NON-LIVING TO THE LIVING.

We think of a time when the earth was without living beings. Non-living matter ordinarily consists of atoms and molecules, of crystals, and of coloidal particles. These, however do not show any of the distinctive qualities of life. Life is a property of protoplasm, and protoplasm consists of coloidal particles in water. In passing from the non-living to the living we are passing from the unorganized to a biologically organized system. The ultimate particles of the living system are self-perpetuating coloidal particles. The essential, ultimate living particles must have the following properties:

1. They must be autonomous or self-perpetuating, taking dead matter and reorganizing this into their own peculiar pattern with their own peculiar properties. These ultimate units are appropriately called *autogens*.
2. They must have the power of self-division after attaining a certain size, and this division is an equational division leaving the two resulting, daughter particles with the same potentialities as the original.
3. They must have the power of correlative interaction so that a number of these ultimate living units are held together in a limited or unitary reaction field.
4. They must have the power or property of intermittent mutation, by which, in isolated cases, a new pattern in one or more of the ultimate biological units or autogens is produced.

Aggregates of one or more types of these autogens would then constitute the primitive bionts, and there may have been an evolutionary series leading up to the lowest known organisms or lowest protoplasts as we have them at present in the autophytic Bacteria. Are there any such bionts, below the organization stage of the simplest protoplasts, in the world at present? Are there "species" which form an ascending ladder toward our simplest organized protoplasts (organisms)? Are disease producing plant viruses of such a nature? If these are bionts, then they need a special technique and method for their study which is neither chemical nor biological as this term applies to organized protoplasts, extending from the lowest known Bacteria to the highest plants and animals. If certain viruses are parasitic bionts, then we would expect them to pass into the contracted dry condition or spore-like state like many of the higher protoplasts and, with the return of favorable moisture and other conditions, to return to the active plasma state.

The viruses appear not to be able to perpetuate themselves except as parasites and saprophytes. This condition could not have been the beginning, as intimated above. No claim as to the nature of viruses is made here. They may be only enzymes, they may be bionts, or they may be organisms. Or known viruses might perhaps come into each of these categories. The problem however of the disease-producing viruses seems to be a problem for the cytologist primarily

If there really are such pre-cellular bionts in existence, they would fall into the first of the ten divisions or subkingdoms of plants evolved during the geological ages and would be true Archeophyta.

Theoretically, in dealing with any sort of abiogenesis, we come sooner or later face to face with the problem of organization, if we believe in evolution at all. What is it that causes an evolution of organization, first of the protoplast itself as the unit (for there is an ascending scale from the lower Bacteria to the well organized protoplasts of all the Metaphyta). and second an evolution in the unitary reaction system of the multicellular individual?

THE TRANSITION TO THE SEXUAL, MULTICELLULAR, DIFFERENTIATED ORGANISMS.

In passing from the Protophyta to the Nematophyta, there is a broad transition belt with no prominent break in the continuity. Three fundamental potentialities arise, two of which are to be seen in their primordial evolutionary stage in the higher Protophyta. We have the evolution of the sex potentiality, the evolution of the multicellular condition, and the evolution of differentiation systems. These three do not appear in the same sequence in the various phyla and classes; so the sex potentiality is taken as the most important characteristic to segregate the first two subkingdoms, the Protophyta and the Nematophyta. The evolution of the multicellular condition and of differentiation is simply the accumulation of various hereditary potentialities which in themselves have no great consequence at the time of their several introductions. But with the introduction of the sex potentiality, which is probably the result of an advanced organization of the protoplast and especially of the nucleus, a profound change takes place in the reaction system of the entire life cycle, giving rise to the dimorphic development of the gametes with attractive properties, resulting in fusion into a unitary system from the two independent units, and to a synapsis of chromosomes at a later period followed by reduction. As a consequence of these two processes, the Mendelian method of hereditary transmissions and interactions is established.

The change from the nonsexual to the sexual apparently was accomplished independently in various phyletic lines and was not dependent either on the multicellular condition or on the presence of vegetative differentiation potentialities. Its appearance was dependent on causes having their origin in the peculiar structure of living matter of a certain degree and type of complexity.

THE TRANSITION BETWEEN THE NEMATOPHYTA AND THE BRYOPHYTA.

The greatest hiatus in the entire plant series occurs between the Nematophyta and the Bryophyta. There is little probability that any recognizable missing links will ever be found in the fossil record to help fill the gap. For geologically these plants evolved long before the paleozoic era. It is practically certain that none have survived to the present day. It is expedient, therefore, to construct a series of hypothetical forms. In the first place the ancestors must have been filamentous green Algæ. The prominent protonema of the Bryophyta and its presence in the lower Pteridophyta fully justify such an assumption. Then this filamentous group gradually built up a multicellular constitution retaining the more primitive potentialities to be active in the juvenile part of the ontogenetic gradient. Sooner or later, with the introduction of solid tissues, plurilocular gametangia were established which by simple, direct transformations evolved into the archegonia and antheridia of the lower Bryophyta. Unicellular and multicellular rhizoids also were probably evolved before the transition and transformation to aerial conditions. The Phaeosporæ have plurilocular gametangia, but the liverworts and mosses evidently did not evolve from the Brown Algæ. They have too many special peculiarities. In a very early stage a normal alternation of generations was established which soon advanced to the typical antithetic type with a completely parasitic diploid sporophyte. No living green Alga has such a cycle. In fact it is not present in any of the living Algæ. One can see that a large number of fundamental morphological and ecological progressions was necessary to bring the procession up to even the lowest bryophyte stage.

Theoretically then, the great hiatus between the Nematophyta and the Bryophyta must be represented by hypothetical forms that were evolving at the same time as the higher Nematophyta. If there were any surviving representatives they would constitute a distinct and important division of the plant kingdom and would appropriately be called Protobryophyta.

THE TRANSITION FROM THE BRYOPHYTA TO THE PTERIDOPHYTA HOMOSPORÆ.

There is a large break between the Bryophytes and Pteridophytes but not nearly so great as that between the Nematophytes and Bryophytes. In this transition, the geological record gives some information and no doubt will disclose many more transition links in the future.

The main advances are as follows:

1. Change from a determinate sporophyte to an indeterminate one.
2. Change from a permanently parasitic sporophyte to an independent mature condition, only the juvenile stage being parasitic.
3. Gradual shifting of the point of origin of the sporangium from the simple terminal bud to a lateral appendage, namely the leaf.
4. Change from determinate death with the end of the reproductive process in the sporophyte, to indefinite long-continued existence not affected by the reproductive process.
5. Change from an unbranched system to a sporophyte either with dichotomous or monopodial branching.
6. Development of a vascular system and in some lines of a cambium layer.
7. Development of roots.
8. Development of leaves.
9. Reduction of the gametophyte.
10. Sinking of the archegonium venter into the tissue of the thallus, or rather recession of the differentiation reaction into the earlier stages of the ontogeny, resulting in a sunken venter with only the archegonial neck differentiating from the archegonial outgrowth.

There is no direct connection with any of the higher Bryophytes although the Anthocerotæ with their sunken archegonial venter are a closely related parallel series. We must then postulate a bryophyte ancestor with a reducing gametophyte, with sunken venter, with a tendency to enlarge the sporophyte into a more efficient reaction system and with a definite progressive tendency to shift the reproductive tissue from the center of the axis to the outside. Since the lower Pteridophyta usually have a rather well-developed protonemal stage they are reasonably derived from the same ancestral stock, namely the green Algæ, as the Bryophytes. They passed through the bryophyte stage and were probably already segregated into the various phyletic groups long before they progressed to the present advanced position of even the lowest living Ferns Two main phyletic lines, at least, are in evidence, the fern line with the evolution of an original cylinder of open vascular bundles and cambium, and a lepidophyte line with a more closed vascular strand, as in our present Lycopods, although these might also have had a more open bundle system until they were definitely specialized into our modern types

As to the order in which the various pteridophyte mutations appeared, one can only guess, because of so little fossil evidence accumulated up to the present. There may have been different sequences in the several phyletic lines. The essentials, of course, were the initiation of a branching ability, the lateral movement of the spore-producing areas with accompanying indeterminateness and independence of the mature sporophyte, and the evolution of leaves and roots from the terminal gowing bud. If efficiency of meristematic growth and dichotomous branching were established before the sprangium had traveled to the margin of the stem or onto a leaf appendage, then there might be continuous vegetative growth in some axes even though others were definitely determinate because of the continuance in the race of a bryophyte type of terminal sporangium. Psilophyton appears to have been a decidedly intermediate plant, fitting into the theoretical series necessary for passing from a bryophyte stage to the lycopod condition. Psilophytons apparently were plants with vigorous growth and dichotomous branching, with no definite leaves and perhaps without roots. They still had large terminal sporangia like a moss or liverwort and these, of course, would end the growth of any branches which produced them, but other branches could continue the vegetative growth. *Rhynia gwynne-vaughani* appears to have been an even more primitive plant of the same series. It apparently had terminal cauline sporangia, vigorous growth as compared with any known bryophyte sporophyte, and dichotomous branching but no roots or leaves. Such leafless branching fossil species with large terminal sporangia are not to be compared with Algæ but with bryophyte sporophytes. Such a comparison indicates four important advances beyond the bryophyte condition as follows: (1), The evolution of long-continued, vigorous growth; (2), the acquirement of an independent mature phase of the sporophyte with the development of a rhizome-like base which could probably act as an absorbing organ; (3), a dichotomous branching system; (4), A dimorphic reaction in the terminal buds so that some developed terminal sporangia like the Bryophytes and some continued the vegetative growth.

There is no definite evidence that the fern series was derived from the lycopod line. The evidence is rather in the opposite direction. The most reasonable assumption, if the Lycopods cannot be derived from ancestral Ferns, is that both types of vascular systems were derived from a moss-like central strand of the primitive stem. Campbell has shown that there is a very direct connection between the Ophioglossales and a bryophyte ancestor something like Anthoceros. The embryology is decidedly bryophyte-like; the first leaf, stem tip and root all coming from the outer segment of the egg. Whatever the ancestral type of the lepidophyte vascular system may have been, we know that it shows the same disposition to scatter in some of the higher Selaginellas as do the bundle systems in the Leptosporangiate Ferns, Monocotyls, and various small groups of Dicotyls. It is becoming evident that at least all the vascular systems of the living plants except perhaps those of the Lepidophyta had their origin from the primitive fern type, namely the circle of open bundles with a cambium cylinder as in the Ophioglossales.

The hiatus between the Bryophytes and the Homosporous Pteridophytes represents a transition which must have contained a large number of groups in a lower stage of evolution than our present Lycopods and Ferns. Rhynia and Psilophyton represent transition forms between the Lycopodiaceæ and their bryophyte ancestors while no ancestral Ferns of the same level are known at present. But fern-like ancestral forms with terminal and perhaps lateral cauline sporangia must have existed. The fern series never evolved a dichotomous branching system and the ancestral groups must either have had unbranched but vigorous sporophytes with an independent mature phase or else they were evolving a rudimentary monopodial branching potentiality. All such plants whether ancestral Lycopods or Ferns were the true Protopteridophyta.

The lowest vascular plants in which the sporangia had traveled from a terminal position to a lateral position on a lateral appendage or leaf probably had alternating zones of sporophylls and foilage leaves just as soon as indeterminate growth was fully established as is the case in all flowerless fern types and in the typical flowerless living Lycopods. For it is a general characteristic of primitive ontogenies to have rhythmical repetitive reactions rather than irregular sequences. Such rhythmical reactions depending on developing gradients, are seen not only in the alternation of zones of sporophylls and foliage leaves but also in the rhythmical appearance of branches or branch whorls on the main stem alternating with branchless zones, as in Araucaria and other Conifers and some species of Magnolia. Any species then which was thrown from the juvenile vegetative condition with foliage leaves to a permanent condition of sporophyll production, until the stopping of growth of the reproductive branches was attained, would indicate a first slight movement toward definite strobilus or flower evolution. In the most primitive condition the sporangia would not be on the leaves but directly on the axis, so systems could develop in which small leaf whorls would alternate with whorls or zones of sporangia.

THE TRANSITION FROM HOMOSPOROUS TO HETEROSPOROUS PLANTS.

For some unknown reason, after the sporophyte has attained a certain degree of advancement in the various phyletic lines, the point of sex determination passes from gametophyte to sporophyte. The general reason is that the orthogenetic progression can continue until the zygote is reached, and this progression is in evidence in many higher phyletic series. The movement is a process in which the time of sex determination continues to gain on the ontogeny until the determinate limit is reached in the fertilized egg or zygote where this evolutionary advancement necessarily comes to an end in the attainment of diecious species. The fact must be emphasized that the transition from sex determination in the haploid gametophyte to the diploid sporophyte is not dependent on the simple or double number of chromosomes nor to any special kind of morphology. It took place in series that had the lepidophyte morphology as well as in series that had the ptenophyte and calamophyte morphology. It took place without reference as to whether a flower had evolved in the system or not. There was a great destruction of forms of plants which had arrived at this stage of evolution. But this is not to be ascribed to the change in sex condition but rather to the increasing helplessness of the gametophyte which at this stage went hand in hand with the evolutionary progression in the time of sex determination. Some of the missing links leading from the Homosporous Ferns to the Cycads have been discovered, namely the Pteridospermæ, but not much progress has been made in uncovering missing links which must have been left behind on the path leading up to the Strobilophyta. There are also very few fossil links known which might aid in solving the problem of the vast isolation of the Anthophyta.

THE TRANSITION TO THE GYMNOSPERMS.

The great advance which culminated in the perfection of the seed was certainly one of the major events in the evolution of organisms. The main movements were, of course, the making of a complete parasite out of the gametophyte; the gradual intercalation of a resting phase, often followed by a long period of dormancy, between the parasitic embryonic phase and the independent mature phase of the sporophyte; and the two-phased parasitic growth of the pollentube. Each of these changes required decided ecological adjustments. The lower Cycadophyta are flowerless plants, like the Ferns, with simple rosettes of sporophylls, while most of the advanced forms attained to the strobilus stage, acquiring a definite, determinate, reproductive axis, as is prominently shown in the higher Cycadeæ. In the Ginkgo series, however, no flower was evolved, although the other important morphological systems advanced to a very high condition. The gymnosperm strobilus is of the same general nature as that which appeared in the Lycopodium and Equisetum lines. It is perfectly evident that the flower had a large number of independent origins, just like the origin of heterospory or various other important, orthogenetic, evolutionary advances, as for example the development of dimorphism between sporophylls and foliage leaves and the attainment of dieciousness. In all the various cases, however, the evolutionary process was the same; namely, the introduction of a determinate potentiality active in the reproductive shoot and the continued movement of this potentiality toward a more definite reaction and a more prompt determination in relation to the ontogenetic gradient of the floral axis.

The primitive types of flowers are represented in Lycopodium, Equisetum, Selaginella, Cycadeoidea, Encephalartos, Araucaria, Magnolia, Ranunculus, and Echinodorus. Extreme types are present in Taxus, Gnetum, Naias, Typha, Wolffia, Corallorrhiza, Monolepis, Peperomia, Casuarina, Salix, Hippuris, Xanthium, and Taraxacum. The attempt to evolve a flower from an inflorescence must be regarded as fantastic and based on anarchistic modes of thought. · If one takes an inventory of the acquirements of complex systems of potentialities possessed by the entire plant, namely the complete compliment of hereditary factors, of any of the extreme types mentioned above, it will be found that the species with reduced flowers have the most complex reaction systems, and that in them the various evolutionary progressions which have been operative from the beginning are also the most advanced in the species which have the most extreme flowers. The various evolutionary movements, although they are mainly independent of each other, show a remarkably consistent, forward progression.

When one makes a study of such a classification as that developed in the Engler system or the proposals put forth by Wettstein and others, where a Magnolia, for example, with its decidedly simple and rhythmical reaction system, is derived from the Gnetales, with their enormous complement of extreme specializations, and evolved through such forms as Casuarina, Quercus, Juglans, etc., or their immediate theoretical ancestors, then the whole scheme appears not only fantastic but the extreme of absurdity.

In the lower Homosporous Pteridophytes there were no doubt series evolved with alternating simple zones or whorls of sporophylls and foliage leaves, or in some cases with lateral cauline sporangia subtended by foliage leaves or bracts. One would expect such types from the fact that the spore-producing activity travels out from the center of the primary stem to the leaf appendages and in some cases even to the epidermis of the leaves; and after a branching system had evolved it often is shifted entirely away from the primary axis to secondary or tertiary axes and their appendages. These special, primitive systems present in some fossil plants give no excuse for pretending to see a reducing, branched inflorescence when the evolution of branching whether dichotomous or monopodial had hardly begun.

The Strobilophyta are much more isolated from the Pteridophyta than the Cycadophyta but not nearly so much as are the Anthophyta. The general evolutionary movements are the same as in the Cycadophyta, only on a more advanced and complex scale. The Araucariales are plainly the most primitive conifers, and from the lowest broad-leaf Araucariaceæ the evolution of the leaf is consistently carried forward to the extremely reduced scale and needle-leaf types. The flower also evolved consistently in the same direction and along with it there is a parallel advance of numerous other characteristics.

Conifers show no evidence of a previous, bisporangiate condition of the flower. But in all three orders, Araucariales, Pinales, and Taxales, both monecious and diecious species are present. Although the movement in the evolution to unisexuality is not closely associated with or dependent on any other evolutionary advance taking place in the plant body, yet there is sometimes a parallelism of evoluting movements as would be expected if evolution is progressing in definite directions. In the Pinales dieciousness is only attained in the most extreme genus, Juniperus, some species of this genus still being monecious and some diecious. In the Taxales which show a consistently higher level in nearly all evolutionary movements, dieciousness is attained quite a number of times in independent genera.

The problem of connecting the Conifers with the Ptenophyta is to find fossil missing links, especially Heterosperous Ferns, but the question arises as to whether these would be recognized as ancestral Conifers even if discovered. The connecting links would be broad-leaved (not necessarily compound) trees; the line finally extending below the level of the presence of flowers and probably of branches.

In passing downard to theoretical ancestors, two conditions are possible for a derivation of monecious and diecious flowers as represented by present Conifers. Differential gradients determining one or the other sexual states in any reproductive bud may have been established before the mutation to determine reproductive axes took place, just as we have monecious flower systems in which one or the other sex condition is temporarily established in the primary axis from which the secondary floral axes branch off. Then with the introduction of reproductive determinateness monosporangiate flowers would naturally follow directly. On the other hand, undiscovered bisporangiate flowers may have preceded the monosporangiate condition, which would lead back to indeterminate reproductive zones with one sexual state present at the beginning stage of development, and through a sex reversal, with the opposite sexual state at the end of the ontogeny of the reproductive zone. Then the introduction of reproductive determinateness would necessarily give bisporangiate flowers. The lack of vestigial structures of the opposite sporophylls is against this hypothesis and would indicate that the conifers never had bisporangiate flowers. The same reasoning may be applied to the living Cycadales in spite of the fact that their relatives, the Bennettitales, had bisporangiate flowers.

The Gneteæ, on the other hand, like many monecious and diecious Angiosperms, plainly had ancestors with bisporangiate flowers, since some of them show definite vestigial structures of the opposite set of sporophylls.

THE TRANSITION TO THE ANGIOSPERMÆ.

As stated previously, the Angiosperms or Anthophyta, did not have their origin in any of the living groups of Gymnosperms. At most the nearest approach to a common ancestry of the two groups might be sought in hypothetical Heterosporous Pteridophytes which would trace back to Eusporangiate Ferns, where both open and closed vascular bundles evolved, comparable to the open and closed bundles of the Dicotyls and Monocotyls. In various Leptosporangiate Ferns there is a strong tendency to close up the leaflets of the sporophylls. This attains extreme development in the Marsileales. Now we will have to assume that somewhere along the line the ancestral Angiosperms passed from the open to the closed megasporophyll. Since the stamens were apparently not involved in the movement it probably did not occur until the group was passing through the Heterosporous Pteridophyte stage or to the seed-bearing condition.

If there were already distinct phyletic lines of ancestral Angiosperms established, then all the lines passed through the same progression. And this is the usual occurrence in all fundamental evolutionary movements. When it comes to general growth habit and form, many of the Monocotyl trees are much nearer the primitive Fern type than any Dicotyls and there is no special reason for supposing that they did not come through the last three subkingdom stages in substantially the same form.

The vascular system of the Monocotyls probably segregated off long before one could speak of Monocotyls and Dicotyls in the modern sense. The same movement developed to a slight extent in many lines of Dicotyls giving scattered and partially closed vascular bundles in many, mostly decidedly advanced Dicotyl groups. Thus, so far as the vascular system is concerned, the "Monocotyls" probably evolved from the "Dicotyls." But when it comes to embryonic structures the evolution was plainly in the opposite direction. The primitive Ferns have one "cotyledon" and the Monocotyls have simply continued this condition, with various minor modifications, while the Dicotyl embryo represents a decided specialization which also appeared, probably independently, in the Cycadophyta and Strobilophyta. The Dicotyl type of embryo advanced in specialization in various Strobilophyta until a whorl of numerous cotyledons was attained. On the other hand, the Dicotyl type of embryo may be transformed into a "Monocotyl" type by the introduction of a factor which suppresses one member, as in Claytonia. The notion that the Monocotyl condition was derived from the Dicotyl by fusion is to be considered only as a survival of an archaic method of morphological reasoning which thought of the plant as being built up of distinct parts rather than as developing through the reaction of hereditary potentialities which were successively evolved and through which the reaction system is changed at the right point in the ontogenetic cycle provided a proper environment is at hand. We know that a change to a suitable environment will often cause a new reaction and bring out structures which never could have appeared in the normal sequence of the phylogenetic history.

The flowers of the Angiosperms are plainly and conclusively strobili, as stated above, of the same general nature as those of Equisetum, Lycopodium, Dioon, and Araucaria. They are determinate, reproductive axes with ordinary, modified sporophylls. They were all of a single primary bisporangiate type originally and the indication is that they evolved about the time when heterospory was attained. From the bisporangiate condition they advanced to the various degrees of moneciousness and dieciousness while at the same time a general evolutionary movement was going on producing a more definite and an earlier action of the determinate potentiality. That the primitive Angiosperms were entomophilous without special adaptations is hardly open to question. Various Ferns, like *Pteris aquilina* for example, have abundant nectaries on their leaves and these are visited by various insects which gather the abundant secretions while the leaves are expanding. No one at present would continue to put forth the foolish teleological claim that such visits were a life and death advantage to the plant or any advantage at all. Some of the Angiosperms had the nectaries from the beginning and some perhaps did not. The presence of an insect environment could not determine the origin of nectaries, although in the presence of an insect environment specializations may evolve which will cause elimination whenever this special insect environment is absent.

With the introduction of branching potentialities and reductions, inflorescences were finally evolved which are of the same general nature and due to the same causes as the inflorescences one finds in the higher Lycopods, in some of the Taxodiaceæ, and in the Gneteæ. The development of a perianth and of a peduncle is again of the same general nature as the development of peduncles or perianths in Equisetum or of peduncles and specialized basal sporophylls in certain Lepidophyta, Cycadophyta, and Strobilophyta. The Angiosperms, developing a definite bisporangiate condition, with the stamens below, obtained a perianth mainly by the transformation of stamens. As special potentialities were added that came into play mainly when the ontogenetic gradient was passing through the zone from vegetative determination to reproductive determination in the flower, the stage was set for special developments on this transition zone, resulting in peduncles and perianths. Neither the Engler system nor Wettstein's speculations can be taken seriously by any one who has advanced along modern lines of discarding teleological evolutionary theories and who thinks of evolution as an orderly mutative process, to account for the taxonomic system; for this system shows the most remarkable orderliness not only in the great fundamental progressions from the most simple to the most complex organisms but also in the sequences of the subordinate phyla and smaller series.

When the claim is made that the Magnolia flower represents the primitive type of flower for all Angiosperms, we are not claiming an immediate monophyletic origin of all existing Angiosperms, except in the broadest sense, any more than when we claim that the strobilus of a Lycopod and the strobilus of a Cycad are exactly homologous structures do we intimate that these two diverse groups had an immediate monophyletic origin. The Protangiosperms must have been evolving as a distinct phylum side by side with the Gymnosperms and at the same time.

There is but one rational view in respect to the evolution and phylogeny of the Anthophyta. They connect with the lower members of the great mother phylum of all the living seed plants, namely with the Ptenophyta. They evolved strobili of the same general nature as the Equisetaceæ, the higher species of Lycopodium, the Selaginellaceæ, the Cycadaceæ and the lower Coniferæ. The lowest living Angiosperms, as stated above, still have these strobilus-like flowers with very moderate modifications, in fact with modifications so slight that one can make a direct comparison with the strobili of Homosporous Pteridophytes. These flowers, in fact all flowers, consist of a main determinate axis bearing sporophylls. In some cases modified sporophylls appear even in very low types; in others there is a direct succession to the foliage leaves below. The flowers are derived from indeterminate axes through mutative processes which involve the development of functional gradients, these gradients not being subject to rejuvenation or repetition normally as in the lower stage where rosettes or zones of sporophylls alternate with the growth of vegetative leaves. The retention of the primitive condition is represented among living higher plants in the carpellate rosettes of Cycas and the carpellate and staminate rosettes on the indeterminate dwarf branches of Ginkgo. From the primitive strobilus type of flower have evolved all the diversified flower types in both Angiosperms and Gymnosperms and the sequence to the extremes can easily be followed out in a host of phylogenetic lines. The evolution resolves itself into a few simple, fundamental movements which were practically the same in all the series.

The botanist who deserves credit above all others for laying the foundation of modern plant phylogeny on a correct and rational basis was Dr. Charles E. Bessey and the writer has often marveled that those who were supposed to have some intimate knowledge of systematic botany, both in America and Europe, could not see the way after it had been pointed out by Bessey, but persisted in phylogenetic speculations and taxonomic arrangements which make a travesty of any rational notion of plant evolution whatever. When the series are in proper order we discover a remarkable system and the actual movements of the evolutionary process become evident. With improper arrangements, like some which are still in high repute and in very general use, the whole system appears hap-hazard and the product of the whims of witches rather than of a rational order of law. One can be sure, however, that the disorder is in the minds of the taxonomists and not in the plant system itself.

I am greatly indebted to Dr. Lois Lampe for the execution of the accompanying chart, which illustrates the remarkable orthogenetic accumulation of the fundamental properties and potentialities in the plant kingdom.

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HABITS OF THE SHORT-TAILED SHREW, BLARINA BREVICAUDA (SAY).

W. J. HAMILTON, JR.

The following notes are presented in the hopes that they may be of interest to students of the smaller mammals. The observations submitted here have been made over a period of six years, commencing in 1924 and continued as time permitted.

MOLTING.

Molting appears to take place without regard to season, and specimens taken in December and June alike show changing coats. The most pronounced change from winter to summer may best be observed in May and June, while specimens taken in November will usually show some indication of a change to winter pelage.

The short summer coat usually makes its appearance on the back, slightly caudad of the shoulders. From here it proceeds backward and forward in no particular manner. Full shedding occupied approximately six weeks in two captive animals.

WEIGHTS.

Average weights of 53 adult males from Ithaca, N. Y., 20.35 gms. Average weights of 27 females from Ithaca, N. Y., 18.3 gms. It would seem that weight is a fair indicator of maturity in this animal, when coupled with the measurements. The health of the individual and the amount of available food are potent factors in determining weight. However, specimens under sixteen grams were never found to be mature. The heaviest shrews secured were two males, that weighed 27 gms. and 26.3 gms., respectively.

RANGE OF THE INDIVIDUAL.

The home range of any mammal is a difficult thing to determine, more so with the smaller forms than with the larger. The range of any Blarina is probably restricted to an acre of ground, while the ranges of two pair or individuals most surely overlap at all times.

As to the numbers, some light may be thrown on this by systematic trapping. The numbers will of course vary with the environment. Where one woodlot will yield upward of a hundred an adjoining field will contain perhaps a single pair. Various writers have endeavored to determine this point. Seton (1909) says:

> "After a fall of snow I walked for a mile through the woods at Cos Cobb and found labyrinths of fresh Blarina tunnels every fifty yards. There was doubtless a Blarina for every system of tunnels, and many of the species were probably not yet represented, as it was but three or four hours since the fresh snow came. This then, affords a minimum gauge of the creature's numbers. In these woods, there were certainly fifty Blarina's to the acre."

Shull (1907) estimates their numbers at four per acre. Brooks (1908) regarding their numbers, says:

> "In less than a week the traps caught over twenty short-tailed shrews under a single chestnut tree."

This can not be considered a good normal index of the shrew population, the shrews being attracted to the weevil larvæ in the chestnuts, as Brooks subsequently points out.

In a tract of woodland where the short-tailed shrew was exceedingly abundant, the writer took nineteen in one night from fifty traps. Trapping was confined to ten yards each side of a path and one hundred and fifty yards along it. In three nights the total catch amounted to thirty-seven. This area totaled 27,000 square feet or about three-fifths of an acre. This gives very little indication of the numbers to the acre in this particular woodland, as the shrews' individual range is not known. It is very likely that these individuals ranged over an area many times as great as the boundaries of my trap line.

In one trap set in a small swale I caught eleven shrews in fifteen nights. Again, in a hilly tract, sparsely wooded, eight Blarina's were caught in a single runway in seventeen days. On another occasion three short-tailed shrews were caught in the same runway in twenty-four hours.

Collecting in a wooded tract that appeared to be favorable to these creatures, I placed out fifty traps and attended them daily for a week. The total catch resulted in two shrews and two deer mice.

From these observations and more made while collecting the writer should judge that there could exist about four pairs of shrews to an acre in a choice locality.

PERIOD OF ACTIVITY.

Blarina is active both by day and night. On several occasions I have seen this shrew, in the wild state, moving about during the brightest hours, but invariably in subdued light or shade. Captive specimens do not avoid light that is not too bright, but cannot stand the bright rays of the sun for more than a few moments without fatal consequences. One which I had captive, when placed in direct sunlight, became at once uneasy, and in a minute appeared very much agitated. It ran about ceaselessly, attempting to find cover, and at the end of four minutes, lay on its side, breathing very hard. Another which I had died in less than ten hours, due, I believe, to the very bright enclosure in which I had placed it. It had no cover.

Over thirty specimens have been taken in open runs between the hours of 7 A. M. and 5 P. M. and examination of the stomach showed they had fed during this time.

While setting traps in a rather dense copse in late May I saw one of these little animals running among the dead leaves at the side of a fallen log. The hour was close to noon and the sun shining brightly, but somewhat diffused by the thick growth of alders. The shrew was apparently hunting insects, as he repeatedly picked up small morsels. A very low chattering, not unlike the faint squeaking of bats, was heard, and this was kept up continually while the animal was under my observation.

Shrews must be fairly sound sleepers. When coiled up in their box, asleep, the lid was raised and no heed paid to it. Even when lightly touched with a pencil they simply stirred slightly.

DISPOSITION.

Are shrews solitary or sociable animals? All the written evidence would point to their being extremely solitary. The oft repeated observation of Merriam, who placed three *Sorex* under a glass, where they immediately fell upon one another, would possibly bear this out. But Brooks (1908) indicates they are not adverse to one another's company when he says:

> "On April 28, 1906, while collecting insects in a woodland near Morgantown, W. Va., I found an open sunny spot where I quietly stood for some time to sweep for passing butterflies. While thus engaged, a rustling in the leaves nearby attracted my attention and approaching noiselessly the part from which the sound proceeded, I saw three short-tailed shrews running about over the leaves, evidently foraging for insects. They were hunting within a few feet of one another, and several times were seen to rush about excitedly, as though in pursuit of some lively game."

Two captive males which I placed together were rather nervous, but this may be attributed to their close confinement. When one touched the other, the latter simply backed off. Indeed, they showed only indifference to one another. Large numbers caught in the same runway over a short period of time would possibly point to their toleration of one another. It appears certain that the male and female are much together during the pre-breeding season.

LOCOMOTION.

Blarina is such a short legged creature that little speed can be made. It usually runs, the tail invariably elevated, much after the fashion of the long-tailed soricids. Very rarely do they jump, yet tracks in the snow sometimes show where the gait changes from a run to a series of short leaps. Captive shrews rarely exhibited this tendency, but on one occasion, when I attempted to lift the nest box containing young, the mother leaped from the floor of her enclosure to her nest box opening, a distance in vertical elevation of about three inches.

The speed is less than *Microtus*. A very slow walker can readily overtake a shrew. They are incessant runners, and never seem to tire, appearing to be embodied with a restless spirit that keeps them forever on the go.

The mole shrew is well adapted for digging in loose soil. The fore paws are wide and strong, slightly larger than the hind feet. In digging, the fore feet are used to start the burrow, but the head and nose soon take up the burden of this task.

Shull (1907) remarking on the digging habits of this animal, says:

> "In this soft soil, the shrew at once thrust its nose, and by violent backward and outward strokes of its forefeet, forced its way through the soil like a wedge. No difficulty was experienced in burrowing 20-30 cm. in a minute."

RUNWAYS.

The burrows and tunnels of this shrew vary considerably. They are from one to two and a half inches in diameter, rarely more. There appear to be two zones, one a few inches below the surface or directly upon it, and one at a considerably deeper level. These two levels are joined at irregular intervals by abrupt connections. The deeper runways will descend from sixteen to twenty-two inches below the surface, but it is uncommon to find where a shrew has ventured lower than this.

Some runs are more frequented than others. For example, certain well-worn runways near the surface of the ground yielded eleven and eight shrews respectively in a fortnight of trapping, while not infrequently others would yield from four to six in a week's time. Others close by would yield a single pair, and continued trapping in the same place would fail to take more. The two runways, regardless of yield, appear little if any different from one another. Often the runs will follow just beneath an old log, sometimes penetrating it when it is rotten enough. Such logs may be fairly honey-combed with the runs of this species, and on one occasion I found the resting nest of this shrew in such a situation.

These animals resort to the runways of meadow mice not infrequently and also are occasionally taken in the wider tunnels of the star-nosed mole and Brewer's mole.

SENSES.

Most scientists are in accord with the statement that sight plays little or no part in aiding the shrew in its hunt for food, the eyes merely allowing it to distinguish between light and darkness. But Brooks (1908) speaking about this species in the wild state, remarks that:

> "The shrew made several frantic but well directed leaps for the cricket, caught it, and immediately darted out of sight beneath the leaves. The precision with which the shrew jumped towards its prey led me to suspect that the sense of sight is more perfect than the diminutive eyes would indicate."

Ryder (1888) made a careful study of Blarina's eye and concluded from a study of the ocular muscles that the eye is capable of adjustment for the direction of vision.

On one occasion I introduced a jumping mouse into an enclosure with a shrew. The shrew made several accurate leaps at the agile *Zapus*, which was always too swift for the shrew. It certainly seemed as if the shrew saw the mouse on this occasion.

The eye is clearly seen when the animal is active, and I certainly think it has greater power than to simply distinguish light from darkness.

Apparently the sense of smell is developed to an average degree. Freshly killed mice, placed six inches from the floor of the shrew's enclosure, apparently baffled the animal. It repeatedly passed underneath the suspended rodent but the sense of smell was not sufficient to direct it to the dead animal. Shull (1907) however, believes that shrews distinguish between empty and occupied snail shells chiefly by their odor.

Hearing is perhaps better developed than the other senses. Many writers allude to the exquisite hearing. One which I was observing in a wooded thicket immediately ran to cover when I made a slight movement. Whether the noise of my foot, or the vibrations caused by it, alarmed the shrew, I am not in a position to say.

VOICE.

In general, the calls of shrews and bats are strikingly similar and one would think of the two orders these animals represented as being very close if voice plays any part in their classification. Dice (1925) speaks of it as "a high musical twitter" while Hahn (1908) says it is almost exactly like the rapid chip-chip-chip of the ground squirrel. Miller (1897) states that when angry, the shrews utter a sound much resembling a red squirrel chatter greatly reduced in volume, while Kennicott (1857) adds of hearing a short clear cry, the voice calling to mind that of the mink, but softer and lower.

A peculiar call, oft repeated when disturbed, was heard from captive specimens. This commenced with a shrill grating note, rather high pitched and ends with a slightly lower pitched chatter, like zeeeee-che-che-che-che. Another note, apparently of contentment, is sometimes heard when the animal is feeding, and is entirely distinct from that of alarm or rage. This is very low and continuous, calling to mind the drowsy twitter of sparrows. The voice is developed at an early age, the young giving a sucking note when eight days old, and capable of a tiny chatter at twenty days.

ENEMIES.

Internal Parasites.

Cestodes were found in the greater majority of intestines examined. One tapeworm was as long as the shrew it was taken from. Ripe proglottids often fill the large intestine and extend it.

Nematodes are very abundant. Small eelworms, orange in color and measuring 16-20 mm. are particularly abundant in the stomach and duodenum, sometimes filling the pyloric orifice and almost closing this opening at times. It is obvious that the great abundance of this ascarid must cause some discomfort and possibly death.

Other roundworms occur just under the integument of the rump and shoulder region, imbedded in the mesenchyme. These worms are enclosed in a tissue sheath, and always coiled. They measure 3-4 mm. in diameter when coiled and average 35 mm. in length when outstretched. There may be twenty to thirty on a single animal.

External Parasites.

Acarinids from Blarina have been determined by Dr. H. E. Ewing. *Campylochirus*, *Parasitus*, *Myobia*, *Liponyssus*, *Laelaps*, *Haemogamasus* and *Ichoronyssus* are the genera determined. Generally mites are found about the inguinal region. Fleas are prevalent on this shrew. Among the species determined are the following: *Ctenophthalmus pseudagyrtes*, *Ctenophthalmus wenmanni*, *Ceratophyllus wickhami*, *Doratopsylla blarinæ* and *Nearctopsylla genalis*.

Predatory Animals.

Among fish, a northern pike, *Esox lucius*, was found to have this shrew in its stomach by the authors of "Fishes of Lake Nipigon." Mr. John Meyer of Ithaca, N. Y. caught an eleven inch rainbow trout that had one of these animals in its stomach. Undoubtedly all predaceous fish would not resist a shrew if opportunity offered.

Among the reptiles, Surface (1906) records shrews from the stomachs of the spotted water snake, pilot snake, rattlesnake and copperhead. In most instances the shrews are not specifically identified. Dr. J. R. Greeley found this shrew in the stomach of a milk snake. A black snake which I opened contained a *Blarina.*

Raptorial birds take a large toll of shrews. Fisher (1893) records the short-tailed shrew from the stomachs of the following: Red-tailed Hawk, Red-shouldered Hawk, Sparrow Hawk, Broad-winged Hawk, Barn Owl, Short-eared Owl, Barred Owl and Great-horned Owl. I found seven *Blarina* skulls in the pellets of a breeding pair or Long-eared Owls. Both the pellets and stomach contents of Barred and Screech Owls have yielded shrews.

Among mammals, Brooks (1908) found the most conspicuous thing about the den of a fox was the dead bodies of the short-tailed shrew. He did not count them but says there must have been twenty or thirty in sight. In the stomachs of *Mustela noveboracensis* and *M. cicognanii* I have determined the mammalian remains as those of this shrew. Among a large number of skunk stomachs examined by the writer, two contained parts of *Blarina.* It is likely preyed upon by a host of others, but whether habitually eaten seems unlikely.

PERIODIC MORTALITY.

Not a few observers state that a decided mortality occurs in this species during the fall. Large numbers are found dead, some without apparent injury. Everman and Clark (1911) record twelve specimens from Lake Maxinkuckee, nine of which were found dead, and all in the month of October.

The same situation is met with in England. Some authors hold that insufficient food is the cause of their death, some that lack of water causes the high toll, while a few attribute the high death rate to predaceous animals, which, finding the shrew distasteful, have dropped it where caught. Adams (1909) writing on this phenomena in England, gives as his impression that the annual loss in the fall is due to nothing more than old age, this being reached in the Common and Lesser Shrew in, roughly, thirteen or fourteen months. This is based solely on the fact that all immature shrews are taken after December.

If there is a decided increase in the death rate of *Blarina* during the autumn, and my observations do not point to this, it may be simply due to the fact that the dead specimens are more readily seen at this season.

Internal parasites, particularly roundworms, appear to be more prevalent or larger at this season, and possibly may be an indirect means of the animal's death at this season. Some specimens examined were so parasitized, especially in the pyloric region of the stomach, that it was a wonder to the writer how food could pass by the obstruction caused by these nematodes.

ECONOMIC IMPORTANCE.

Most writers are in accord in ranking this shrew high as a direct aid in keeping down the host of injurious insects and mice. Shull has, I believe, greatly over-rated their importance in holding in check the meadow mouse. He has based the food eaten by these shrews on the relative abundance of various items in the swamp region studied. Shull did not know the predilections regarding food these animals exhibited in the wild state. He estimated four shrews to an acre, and decided that on a farm of one hundred acres, these shrews would account for 38,400. But the writer's studies (Hamilton, 1930) of the food of Blarina show that of 244 specimens examined in the flesh, only 4 contained mouse remains.

It is my opinion that the economic importance that has been credited to shrews has been greatly exaggerated. Shrews seldom occur in numbers sufficient to be of any real significance in cultivated areas. This animal usually prefers a habitat unsuited to crops, and while they may devour insects in large numbers, they certainly do not distinguish between noxious and beneficial forms. It is true that in a given locality they may be a potent factor in overcoming a small outbreak of a dangerous pest, but this is exceptional. This shrew is said to be the principal enemy of the larch sawfly in New Brunswick, and is credited with eating forty per cent of the cocoons. Brooks has shown that it may check the chestnut worm (*Balaninus*) in a small locality.

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LeCONTE'S EPITOME OF EVOLUTION

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As has been pointed out by various writers, the history of the evolution idea is not a brief one. Many thinkers—the ancient Greeks, the early theologians, the eighteenth- and nineteenth-century philosophers and biologists—have directed their attention to the difficult and unsolved problem of the origin and development of life, of society and of the universe. As we trace through the history of thought, with the light which science has given us, we observe that some of the great thinkers who have wrestled with this problem of development have made contributions of inestimable value in spite of their meager scientific knowledge and inadequate observations; others, due to the same limitations, submerged their more valuable thoughts in a host of naïve ideas; still others made no advances but merely summarized and organized the ideas and suggestions of those who preceded them. As Lucretius summed up all the teachings of the non-Aristotelian philosophy, so LeConte epitomized the major pre-twentieth-century ideas concerning evolution. Let us, then, examine LeConte's idea and see what there is in it of value.

In the first chapter of his book, *Evolution**, which first appeared in 1887, LeConte deals with the scope and definition of evolution. In order to objectify his notions, he refers again and again to the development of the egg as the type form of all evolution.

> Every one is familiar with the main facts connected with the development of an egg. We all know that it begins as a microscopic germ-cell, then grows into an egg, then organizes into a chick, and finally grows into a cock; and that the whole process follows some general, well-recognized law. Now, this process is evolution. It is more—it is *the* type of all evolution. It is that from which we get our idea of evolution, and without which there would be no such word. Whenever and

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*Joseph LeConte. *Evolution, Its Nature, Its Evidences, and Its Relation to Religious Thought*, (Second Edition, Revised), 1899. New York: D. Appleton and Company.

wherever we find a process of change more or less resembling this, and following laws similar to those determining the development of an egg, we call it evolution.*

LeConte, like Spencer, says that evolution, as a process, is not confined to the development of one thing, as the egg, nor as a doctrine is it confined to one science, as biology, "The process pervades the whole universe, and the doctrine concerns alike every department of science—yes, every department of human thought." All things may be studied from two points of view. From the one view we are concerned with things as they are; but from the other, with the process by which they become what they are. "This 'law of becoming' ", says LeConte, "in all things—this universal law of progressive inter-connected change—may be called the law of continuity." This law asserts that there is a universal causal relation between things in time. "This is the universal law of evolution." Thus evolution is a single process which unifies and binds together all things into a causal and temporal relationship. Although LeConte does speak of evolution as being universal, he seems to limit his discussion and thinking almost exclusively to biological evolution. "If there be any evolution, *par excellence*, it is evolution of the individual or embryonic development."

Now that we have an idea of LeConte's general approach to the problem of development, we are ready for the statement of his definition which is as follows: "Evolution is (1) continuous *progressive change*, (2) *according to certain laws*, (3) and by means of *resident forces*."† Since he takes embryonic development as his type for all evolution, he assumes that everyone will admit that his definition is completely realized in this process of development. "The change here is certainly continuously progressive; it is according to certain well ascertained laws; it is by forces (vital forces) resident in the egg itself." Since, then, this definition applies to the type form, he concludes that it applies equally well to all things and hence is a valid definition.

Since we are not satisfied with the mere statement of his definition, let us analyze it carefully and see what he means by each of the elements which it embraces. First, what does

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*LeConte: *Evolution*, p. 3.

†Loc. cit., p. 8.

LeConte mean by *progressive change?* We shall best understand his meaning from his own statements. He discusses this first element of his definition in three paragraphs and illustrates his idea by the Ontogenetic series, the Taxomonic series, and the Phylogenetic series. Of the first he says:

> "Every individual animal body—say man's—has become what it now is by a gradual process. Commencing as a microscopic spherule of living but apparently unorganized protoplasm, it gradually added cell to cell, tissue to tissue, organ to organ, and function to function; thus becoming more and more complex in the mutual action of its correlated parts, as it passed successively through the stages of germ, egg, embryo, and infant to maturity. This ascending series of genetically connected stages is called the embryonic or *Ontogenetic* series."*

Similarly, he discusses the Taxonomic series and the Phylogenetic series, and in a sentence closes that section by saying: "It will be admitted, then, that we find *progressive change* in organic forms throughout geologic times." Does this make clear to us what "progressive change" is? It is true that in the individual we have the stages of germ, egg, embryo, infant and maturity. Also in examining the rock strata, we find simpler forms of life in the lower levels and more complex in the higher; but a mere statement of these facts does not explain to us what progressive change is. What is meant by change which is progressive? LeConte makes extensive use of the analogy of the branching tree of life in which he represents progressive change by the branches which go upward. Manifestly to say that progressive change is change upwards means nothing. If, however, he means by *up* increasing complexity, then his statements bear a little more meaning. But is all change in the direction of increasing complexity? Is increasing complexity necessary to change before we may call it evolution, or may we call any process of change evolution? These are some of the questions which confront us, and which LeConte does not answer.

When we study the earth's history we find, as we progress through the Eozoic, Palaeozoic, Mesozoic, Genozoic and Psychozoic periods, there an indication of a progression in life from simple to complex. Since we admit that there have been changes, we must also assume some process of change which we may call progressive if by it we mean improvement—improvement in adaptation. This is probably what LeConte meant. Evolution, then, is a process of change, each change being an improvement in adaptation to the environment, and resulting in an increase in complexity.

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*Loc. cit., p. 9.

But this is not all evolution is. It is progressive change, but also change "according to certain laws." What are these laws? LeConte says: "I have been accustomed to formulate them thus: a. The law of differentiation; b. The law of progress of the whole; c. The law of cyclical movement."*

First let us consider the law of differentiation. Taking again the type form of evolution the development of the egg—first is the germ cell which as it divides and subdivides forms the egg. As cell division continues different aggregates of cells are set aside for different purposes: some form the ectoderm germ-layer which later forms the nervous system; others the entoderm layer from which is formed the nutritive system; and still others the mesoderm from which the circulatory system is formed. Thus there is an increasing differentiation among the cells resulting in greater specialization. Also, in the case of phylogenetic development, if we trace backward, we find that the various specialized types merge to form one branch, and the various branches one main trunk. "From such a common trunk, by successive branching and rebranching, each branch taking a different direction, and all growing wider and wider apart (differentiation), have been gradually generated all the diversified forms which we see at the present day. The last leafy ramifications—flower-bearing and fruit-bearing—of this tree of life, are the fauna and flora of the present epoch. The law might be called the law of ramification, of specialization of the parts, and diversification of the whole."†

His second law is the law of progress of the whole. LeConte assumes that there is a progress of the whole, but not necessarily a progress of all the parts of that whole. He seems to have a special idea of progress, namely, that progress is *up*—the passing of something to something else which is higher. He undoubtedly falls into this error by using the analogy of the tree. He speaks of some cells as advancing "to the dignity of brain cells," while "other cells descend to the position of kidney-cells." This seems to be a purely anatomical distinction of higher and lower, and unwarranted from the point of view of development. What does he mean by the whole? Apparently we may mark off any unity we desire and call it "the whole." Thus within this whole are units each of which may be taken as a whole necessarily in progress, and within each of these other units and so *ad infinitum*. This being true there could be no degeneration, if degeneration is the opposite of progress. Thus, we are left in mid-air, so to speak, as to the meaning of his second law. He does, however, make one statement which may bring us on a more solid footing. "But here, also," he says in speaking of the specialization of different cells for various functions, "the highest cells are successively higher, and the whole aggregate is successively nobler and more complex." The last two words are the significant ones, for if he means by progress of the whole an increase in complexity, then we have here the same element which we found in the first part of his definition.

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*Loc. cit., p. 11.

†Loc. cit., p. 13.

The last law is that of cyclical movement. Development is not uniform but in cycles. Each wave or cycle rises higher than the preceding one and then declines, and another wave comes and mounts still higher. The molluscs of the Silurian age dominated the earth, but they declined and gave place to the fishes which rose above the molluscs because of their greater complexity of structure and function. They too, however, declined and today hold a lowly position because the reptiles, mammals and man have successively reached points higher and higher than that of the fishes. These, LeConte calls, cycles of development. He applies this law to the development of society where he thinks it is quite conspicuous. He says:

> "Society everywhere advances, not uniformly, but by successive waves, each higher than the last; each urged by a new and higher social force, and embodying a new and higher phase of civilization. Again, as each phase declines, its characteristic social force is not lost, but becomes incorporated into the next higher phase as a subordinate principle, and thus the social organism as a whole becomes not only higher and higher, but also more and more complex in the mutual relations of its interacting social forces."*

This may be true, but it does not explain why social forces come in waves, nor why each is higher than the last. To strike at the root of the matter we must know the meaning of that vague term "social forces." To say that the development of civilization happens thus and so does not explain it. We ask further, Why does it happen thus and so? Thus instead of finding a partial explanation in this law, we find it suggesting further questions.

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*Loc. cit., p. 26.

Now that we have these three laws in mind, let us pause a moment and consider what LeConte means by the phrase, "according to certain laws." Of course, he is referring to the three laws which we have just discussed above. The question which arises, then, is, Do these three laws exhaust all the laws of evolution? Apparently LeConte thinks so for he does not mention any others. What, then, do we have thus far? The second law– progress of the whole—we have found bears little meaning; the third law—cyclical movement—is unimportant and practically negligible, as he himself admits, and so we have remaining only the law of differentiation, and "resident forces." This latter concept we shall now consider.

The third and important element of LeConte's definition is, "that the *forces* or causes of evolution are *natural;* that they reside in the thing developing and in the reacting environment."* The important thought, then, is that the forces are *natural* and *resident.* This is true, LeConte says, of embryonic development—the forces in the embryo are natural and they are resident. Is this true of all evolution? First we must see what he means by these two terms, "natural" and 'resident." In discussing these he says:

> "Before stating the two opposite views of the cause of evolution, it is necessary to remind the reader that when the evolutionist speaks of the forces that determine progressive changes in organic forms as *resident* or *inherent,* all that he means, or ought to mean, is that they are resident in the same sense as all natural forces are resident; in the same sense that the vital forces of the embryo are resident in the embryo, or that the forces of the development of the solar system according to the nebular or any other cosmogonic hypotheses are resident in that system. In other words, they mean only that they are *natural,* not supernatural. This does not, of course, touch that deeper, that deepest of all questions, viz., the essential *nature and origin of natural forces;* how far they are independent and self-existent, and how far they are only modes of divine energy."†

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*Loc. cit., p. 28.

†Loc. cit., pp. 28–29.

Thus we are to understand that "resident" and "natural" forces are one and the same. From this quotation, we might be led to believe that LeConte is presuming too much; but when we turn to the third part of his book—*The Relation of Evolution to Religious Thought*—we find a clearer statement of his concept.

In discussing this point of natural law he says:

> "It is the bringing together and complete reconciliation of the two apparently antagonistic and mutually excluding views of *direct agency* and *natural law*. Such reconciliation we have already seen is the true test of a rational philosophy. It is the belief in a God not far away beyond our reach, who once long ago enacted laws and created forces which continue of themselves to run the machine we call Nature, but a God *immanent*, a God resident *in* Nature, at all times and in all places directing every event and determining every phenomena. . . . . According to this view the phenomena of Nature are naught else than objectified modes of divine thought, the forces of Nature naught else than different forms of one omnipresent divine energy or will, the laws of Nature naught else than the regular modes of operation of that divine will, invariable because He is unchangeable. According to this view the law of gravitation is naught else than the mode of operation of the divine energy in sustaining the cosmos—the divine method of sustentation; the law of evolution naught else than the mode of operation of the same divine energy in originating and developing the cosmos—the divine method of creation; . . . In a word, according to this view, there is no real efficient force but spirit, and no real *independent* existence but God."*

Thus God is immanent in Nature; He is the resident and natural forces which account for evolution. Evolution is His method of creation. Thus, when LeConte says, "by means of resident forces," he means God, Divine Will or Vital Force. To merely state that evolution is "due to resident forces" adds nothing to the elucidation of the *nature of the process* of development. Thus although LeConte's statement may be perfectly true, it does not go far enough; it does not answer our questions nor solve our difficulties. We wish to penetrate further into the problem and discover, if possible, the nature of these resident forces, why they are resident, and how they have produced that which is in evidence.

Let us sum up LeConte's definition of evolution as we have interpreted it. Evolution is change, in the direction of greater complexity, and differentiation due to a Vital Force. This is apparently all that we have left that is meaningful. Thus we see that there is nothing expressed in this definition which was not expressed by other thinkers before LeConte; he merely brings some of these thoughts together to form one concept. Change, we know was suggested by Heraclitus; the idea of complexity we find in Lamarck, Darwin and the Neo-Darwinians; differentiation was emphasized by Spencer, and Vital Force or God is a religious concept which we find in the history of evolutionary thought as early as Aristotle. Thus as we come to the close of our discussion of LeConte's contribution to evolutionary thought, we realize that it is rather significant that he wrote at the close of the nineteenth century for he epitomized the major ideas concerning evolution which were presented by thinkers who came before him. LeConte significantly marks the close of a long period in the history of evolutionary thought.

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*Loc. cit., pp. 300-301.

OBSERVATIONS ON *CERCARIA GORGONOCEPHALA* WARD.

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Since the Ohio State University Lake Laboratory moved to Put-in-Bay in 1918 there have been found each summer specimens of the compound cercaria discovered in that locality in 1898 by Dr. H. B. Ward.

The primary host and the adult worm are not yet identified but the life history must run roughly like this: The snail Goniobasis is very probably the secondary host and from it the cercaria come, numbers at a time, and fuse together by their tails. The mass of cercariæ with each cercaria tail extending and contracting drifts about as a sort of living bait for some aquatic creature, either a secondary or the primary host from which the embryoes reinfect Goniobasis.

There is no evidence of any purposive locomotion, though the mass can change its position in the water. On a bright sunny day around noon, if the water is quiet, a half hour of surface towing from the Gibraltar dock will usually yield one or two specimens. By inference one would assume that on a cloudy day they might be found at a little depth.

The evidence for Goniobasis is as follows: About the first of August, 1920, as the session was closing, Dr. F. H. Krecker called me over to see a Goniobasis which he had removed from the shell. As I looked through the microscope he jabbed the kidney region of the snail with a needle and out of the opening there sprayed numerous cercaria in a way that I can compare only to a "flower-pot" fire work as it is discharging. These cercaria had sticky tails and would attach to a needle or scalpel which touched the tails. I could see no accumulation of these artificially freed specimens into knots, however.

When ripe the cercaria must be released from the snail in groups or waves and as they writhe about the tails collide and stick, until balls of 25 to 60 individuals are formed. Fig. 1, photograph.

The cercaria tails are made up of two parts, the distal portions glandular, (Fig. 2) as a whole or in part, and the proximal parts strongly extensible. As long as the cercariæ are in place on the tails they are kept in constant motion, some tails contracting while others are extending, which makes the specific name very realistic.

The longer such a group drifts, the fewer cercariæ remain, and when all are lost the quiet ball of permanently contracted tails may be found at the bottom of the container.

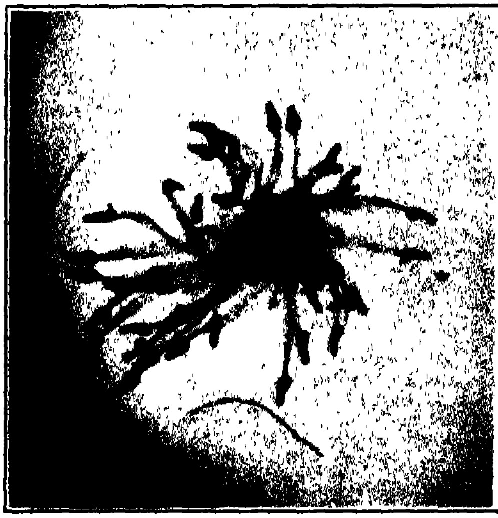

FIG. 1.
Cercaria gorgonocephala. Photo × 25.

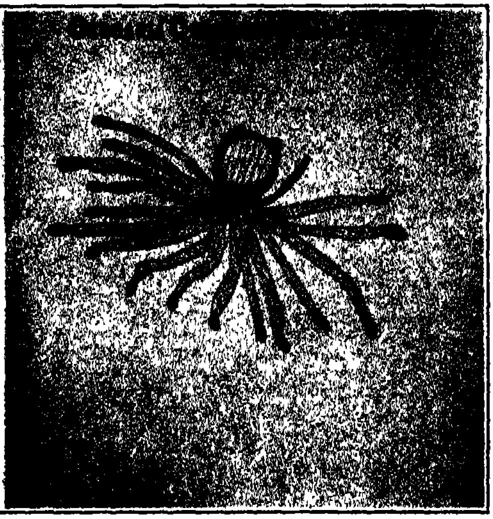

FIG. 2.
Photo of diagram based on camera sketch.

On July 30, 1929, a specimen was taken from the surface of the harbor by the dock which had a bubble of air enclosed by the free ends of the glandular portions of the tails. (Fig. 2). As a result the whole combination was floating about on the surface of the water much as a Portuguese man-of-war may float, and the cercaria were being thrust downward and outward as they extended. It was difficult to keep the creatures under observation because the breath of the observer carried the mass out of the field of the microscope.

The compound specimen photographed in figures 1 is less than 2 mm. in diameter as contracted. Single specimens are shown in figures 3 and 4 and the tip of the tail from which the animal has been lost in figure 5. The separate nuclei show rather plainly in these specimens. The preserved animal is less than 0.2 mm. in length and half that in width at the widest part. Figure 4 is put in to show the point on the dorsal side at which the tail is attached.

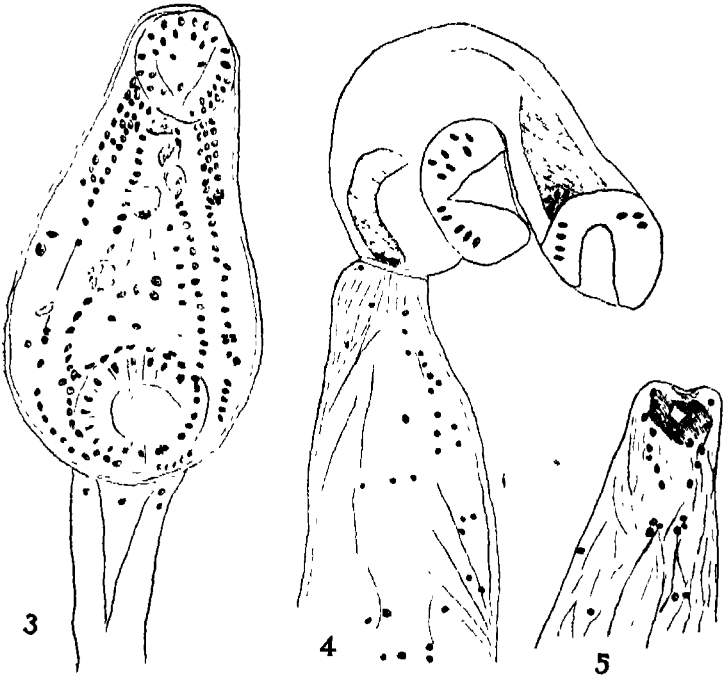

FIG. 3. Ventral view, one cercaria.
FIG. 4. Lateral view, one cercaria and attachment to tail.
FIG. 5. End of tail with cercaria lost.

Whatever the balance of the life history, this grouping of the cercaria into a mass, whether floating or submerged, and the constant motion of the separate parts makes an adaptation for infecting the next aquatic host as a part of its food that can hardly be surpassed.

A SECTIONING CHAMBER.

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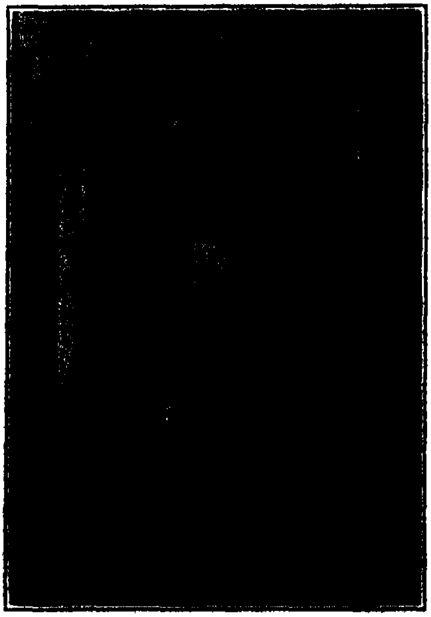
Miami University.

All who have had to do with paraffin sectioning in a small and crowded laboratory know the disadvantages. When the microtome is in use windows may not be opened, no one may walk rapidly across the floor in the vicinity, at times even loud speaking may be disastrous.



A Sectioning Chamber.

We have a laboratory, 20 feet by 22, in which we try to take care of the class in histology and embryology. Thus far the highest number of students registered has been twenty. By putting in a third laboratory period during the week and alternating some students on the two regular days it is possible to furnish each student a place to work.

The common paraffin bath and the microtome are in this room. The difficulties connected with the use of paraffin in a single bath by so many students are great and are endurable only as long as consideration is shown by the users for each other.

The microtome difficulty has been to a great degree eliminated by the use of a chamber three feet ten inches square and six feet nine inches in height, constructed with glass on all sides as shown in the cut. One side has double sliding doors, twenty-one inches wide, which overlap each other when closed and which may be so pushed as to make an entrance either front or back. There is a heavy shelf running around two sides of the compartment at the level of the glass. On this shelf is clamped the microtome and it gives room for the box for the paraffin ribbon and for the heater mentioned below. Beneath the microtome shelf is a large ventilator, 18 inches by 8 inches, and in the roof there is another, 12 inches square.

When the doors are closed a radiant heater (600 watts, because no lesser heat could be obtained) placed on the shelf and pointed toward the microtome will very quickly raise the temperature of the chamber to the point where paraffin will section if the outside room temperature is at all endurable. Usually the heater is cut off before actual sectioning takes place and its connection is replaced by that to an electric lamp on the roof of the chamber.

Thus far no student knows by experience anything about that frictional electricity which sometimes cleaves a paraffin ribbon into its component sections and causes them to flit in all directions.

Due to the amount of glass used in the construction of the compartment, the laboratory room is not at all darkened by it.

It is also a protection against dust.

I wish I might boast that I had thought out this laboratory improvement, but it must be confessed that the chamber was made for an entirely different purpose for another department and then discarded. It took ten years of seeing it in a lumber room to envisage its function.

The convenience of being able to use the microtome at almost any time, either in the cold of winter with a stiff outside breeze, or in the warmer weather with the laboratory windows wide open, makes this a very valuable laboratory adjunct, worth all it costs either in space or appropriation.

DIURNAL VARIATIONS IN THE AMOUNT OF DISSOLVED OXYGEN, ALKALINITY, AND FREE AMMONIA IN CERTAIN FISH PONDS AT FAIRPORT, (IOWA).

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INTRODUCTION.

Some preliminary observations made during the summers of 1927 and 1928 (Wiebe, 1930) made it apparent that the changes in the amount of dissolved oxygen and the alkalinity that occur in a pond within a 24-hour period are as large if not larger than the seasonal change where, for instance, the samples are taken regularly at 8 A. M. For this reason it was decided in 1929 to make a series of tests to determine the extent of the diurnal variations in dissolved oxygen, alkalinity, and in some instances ammonia nitrogen. Diurnal changes in the gaseous constituents of river water have been studied by Butcher et al. (1927–1928).

RESULTS AND DISCUSSION.

The first series was made on a pond called D-10 that has an area of 3.54 acres, on June 6–7, 1929. The water had a depth of 7.5 at the place of sampling. A small amount of plankton was present in the pond. The sky was clear during the day. The results for this series are shown in Table I. This table shows that the variations in the absolute amount of dissolved oxygen were relatively small. The percent of saturation on the surface rose from 105.53% at 8 A. M. to 125.76% at 4 P. M. It then decreased to 102.39% at 5 A. M. the next day. On the bottom the percent of saturation rose from 94.64% at 8 A. M. to 107.69% at 4 P. M. At 5 A. M. on June 7, it was down to 90.47%. The variations in free ammonia nitrogen were very small. The water at the surface was alkaline to phenolphthalein throughout the entire test period. This means there was a deficiency in free CO_2. This deficiency ranged from 2.26 p. p. m. to 5.65 p. p. m. On the bottom there was some free CO_2 at all times. This varied from a minimum of 1.13 p. p. m. to a maximum of 5.65 p. p. m.

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TABLE I.

Table I Shows for D-10 Dissolved Oxygen, free CO_2, and Ammonia Nitrogen in Parts per Million. Percentage of Saturation for Dissolved Oxygen are also Shown.

Date	O_2		Percent Saturation		NH_3	N	Free CO_2	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
6-6-29								
8 A. M.....	10.08	9.18	105.53	94.64	.054	.052	—2.26	2.26
11 A. M....	10.80	9.72	108.67	98.94	.054	.050	—3.39	2.26
2 P. M....	10.73	.... .	122.98	. ..	.052	052	—5.65	1.13
4 P. M. . .	10.86	10.11	125 76	107.69	..	..	—5.65	1.13
7 P. M...	10.56	9.93	120.00	105.00	......	.. .. .	—5.65	2 26
10 P. M... .	9.57	9.96	108.72	105.07	.052	.051	—4.52	2.26
6-7-29								
1 A. M ..	9.51		104.73	.		..	—4.52	.
5 A. M. ..	9.39	8.58	102.39	90 47	.050	.050	—2.26	5.65

TABLE II.

Table II Shows for D-3 Value for Dissolved Oxygen, Phenolphthalein Alkalinity and Ammonia Nitrogen in Parts per Million. Percentage of Saturation for Dissolved Oxygen are also Shown.

Date	Dissolved Oxygen		Percent Saturation		NH_3	Nitrogen	Phenolphthalein Alk.	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
7-2-29								
8 A. M. .	10.22	8.84	114.70	97.35	.052	.040	30.51	27.12
11 A. M. ...	11.34	10.78	134.12	118.72	.028	.028	31.64	27.12
2 P. M.. ...	11.52	12.64	142.74	150.83	.025	.025	31.64	39.55
5 P. M......	11.90	14.87	151.68	189.90	.032	.032	33.90	37.29
8 P. M......	11.15	13.76	131.87	167.39	.026	.028	31.64	33.9
12 P. M. ..	11.34	12.83	132.94	153.10	.032	.026	.	. .
7-3-29								
2 A. M	12.64	....	148.18	. ...	... ...	... . .	......	...
3:30 A. M...	12.64	11.15	145.62	128.45	.032	.032	. ..	.
5:30 A. M...	11.52	7.99	130.46	87.99	......	. .	.... .	...
9:00 A. M...	11.90	10.59	135.92	116.63	.027	.028	. ....	. ..

Table II gives the result for a series of determinations made on a pond called D-3 that has an area of approximately 0.9 acre and a depth of 5 feet at the sampling point. This series was run on July 2–3, 1929. This pond had a good crop of Aphanizomenon at this time. It was approaching the state of water bloom. The dissolved oxygen in the surface samples varied from 10.22 p. p. m. to 12.64 p. p. m. and the percent of saturation from 114.70% to 151.68%. In the bottom samples the dissolved oxygen ranged from 8.84 p. p. m. at 8 A. M. July 2, to 14.87 p. p. m. at 5 P. M. At 5:30 the next morning it was down to 7.99 p. p. m. The percent of saturation ranged from 97.35% at 8 A. M. to 189.90% at 5 P. M. Then at 5:30 A. M. July 3, the percent saturation was down to 87.99%. The ammonia nitrogen showed the largest change between 8 and 11 A. M. After that the changes were relatively small. Alkalinity determinations were made from 8 A. M. to 5 P. M. The water was always strongly alkaline to phenolphthalein, showing that a free CO_2 deficiency existed. The changes in alkalinity were small in the surface samples. In the bottom samples the alkalinity varied from 27.12 p. p. m. at 8 A. M. to 39.55 p. p. m. at 5 P. M. At 8 P. M. it was down to 33.9 p. p. m.

TABLE III.

Table III Shows Values for C-2 and C-3 for Dissolved Oxygen, Phenolphthalein Alkalinity in Parts per Million. Percentages of Saturation for Dissolved Oxygen are also Shown.

Date	Dissolved Oxygen	C-2 Percent Saturation	Phenolphthalein Alk.	Dissolved Oxygen	C-3 Percent Saturation	Phenolphthalein Alk.
8-16-29						
8 A. M.	11.89	125.93	27.12	11 28	124.72	25.99
10 A. M.	13.93	156.90	28.25	13.68	154.21	29.38
12 N.	....	... ...	36 16	19.22	223.35	41.80
2 P. M.	20 18	240 81	44.07	21.98	262.29	44.07
3 P. M.	20.42	243.67	45.2	25.94	312.65	51 98
4 P. M.	21.74	259.42	45.2	24.85	297.67	57.63
6 P. M.	19 70	233 76	48.59	24.25	289.37	61.02
8 P. M.	......	....	47.46	22.69	258.96	57.63
10 P. M	18.98	216 66	42.94	20.19	230.61	51.98
8-17-29						
1 A. M.	17.18	191 69	40.68	18.24	204.70	42.94
2 A. M	14 89	167 11	38.42	17.29	192.32	41.80
3 A. M.	14 41	161 40	38.42	16.09	178.97	....
4 A. M.	14 41	161.40	36.16	15.61	173.63	42.94
5 A. M.	13.09	144.16	36.16	13.81	152.09	....
6 A. M.	11.65	128.30	32.77	13.10	143.42	32.77
7 A. M.	13.69	151.37	32.77	14.64	161 23	35.03
8 A. M	13.89	154.50	36.16	16.33	181.64	39.55

The fact that greater variations in dissolved oxygen and alkalinity occurred in the bottom samples than in the surface samples is accounted for by a peculiar habit of the alga, Aphanizomenon. This alga reacts negatively to strong sunlight. So on a clear day after the sun gets up fairly high in the sky this alga begins to move downward. During the night it migrates again into the upper strata. This is what happened on the day when this series of tests was run. This behavior of Aphanizomenon, I think, accounts also for the rise in the dissolved oxygen at the surface during the night.

Table III presents the results of a series of tests made on the waters of two small concrete ponds. These ponds, C-2 and C-3, each have an area of 378 square feet. The depth of the water is 14 inches at one end and 20 inches at the other. These ponds were in a state of water bloom consisting of a number of species of green and blue-green algæ. The algæ in these ponds were so thick that the transparency of the water was reduced to a few inches. Only surface samples were taken in this case. The percent of saturation in C-2 ranged from 125.93% at 8 A. M. August 16, 1929, to 259.42% at 4 P. M. on the same date. At 6 o'clock the next morning the percent of saturation was down to 128.30%. In C-3 the percent of saturation of dissolved oxygen varied from 124.72% at 8 A. M. to 312.65% at 3 P. M. on the same date. The following morning at 6 o'clock it was down to 143.42%. The water in both ponds was strongly alkaline throughout the entire test period. This again shows the entire absence of free CO_2. In C-2 the range in alkalinity was from 27.12 p. p. m. to 48.59 p. p. m. Then it decreased to 32.77 p. p. m. In C-3 the changes were from 25.99 p. p. m. to 61.02 p. p. m. and then to 32.77 p. p. m.

Table IV shows another set of determinations made on the ponds discussed in the preceding paragraph. In this case samples were taken from the bottom as well as from the surface. The condition of water-bloom still persisted. At 8 A. M. September 4, the percent of saturation with O_2 amounted to 88.9% at the surface of C-2; at 4 P. M. this had risen to 267.90%. The next day at 8 A. M. it stood at 52.34%; at 4 P. M. it was up to 254.72%. At 8 A. M. on September 6, it was down to 114.45% again. The table shows that large changes in the percent of saturation also occurred in the bottom samples. The phenolphthalein alkalinity in the surface samples of C-2 ranged from 23.73 p. p. m. to 67.80 p. p. m. to 32.77 p. p. m. to 62.15 p. p. m. and finally to 45.2 p. p. m. Large changes

FIGURE 1.

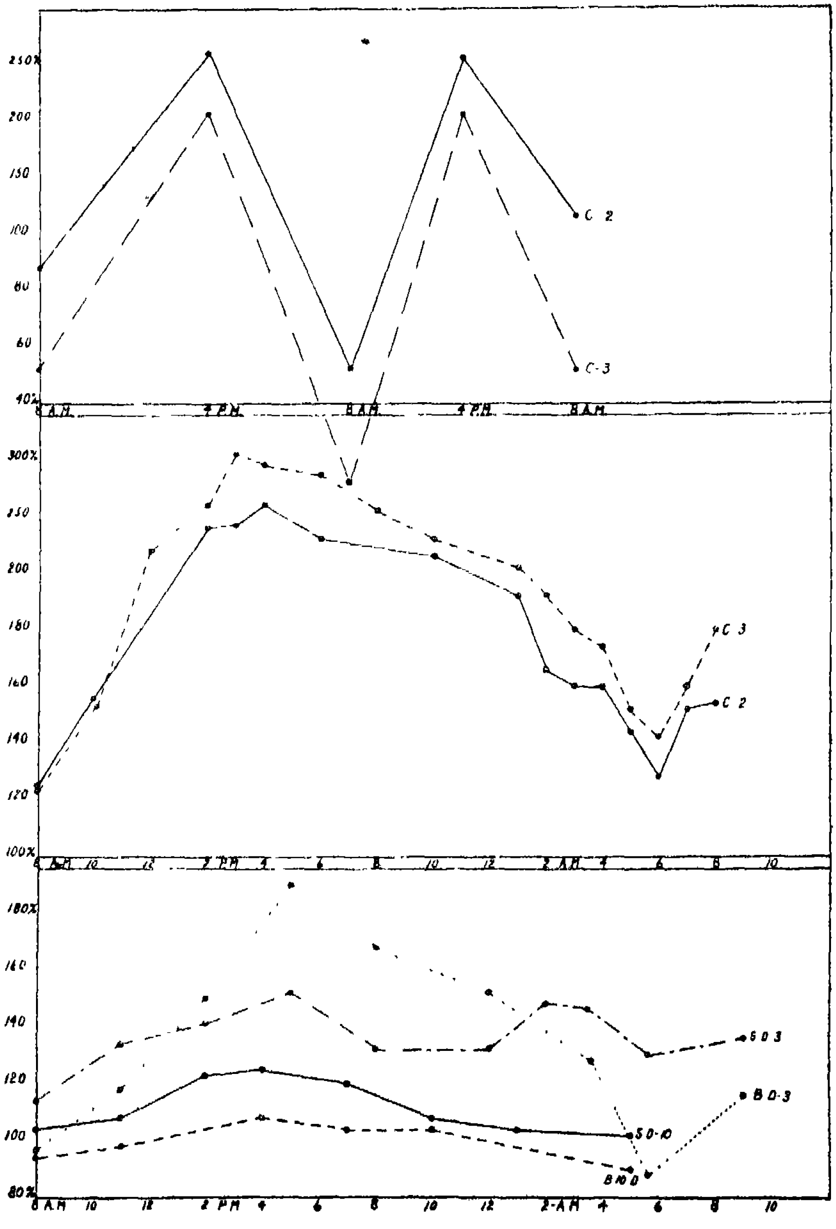

FIG. 1. Variations in the percentage of saturation of dissolved oxygen. C and D indicate pond series; S stands for surface and B for bottom.

occurred also in the alkalinity of the bottom samples in C-2. The results for C-3 are essentially similar to those for C-2, i. e., the O_2 and the alkalinity increased during the day and decreased during the night. The variations in the percentages of saturation with dissolved oxygen in D-10, D-3, and for the first two sets of experiments on the C-ponds are shown graphically in Fig. 1. The graphs were prepared by Mr. J. B. Southall.

TABLE IV.

Table 4 Shows Values for Dissolved Oxygen, Phenolphthalein Alkalinity in Parts per Million. Percentages of Saturation are also Shown.

Date	Dissolved Oxygen		Percent Saturation		Phenolphthalein Alkalinity	
	C-2	C-3	C-2	C-3	C-2	C-3
9-4-29 8 A. M.	7.85	4.36	88.9	52.04	23.73	19.21
	5.93	1.91	70.12	22.59	22.60	19.21
5 P. M.	21.62	16.92	267.90	205.83	67.80	67.80
	15.34	11.68	188.33	140.72	54.24	54.25
9-5-29 8 A. M.	4.70	1.06	52.34	11.55	32.77	14.69
	4.02	1.06	44.27	11.67	33.90	16.95
4 P. M.	21.11	17.62	254.72	204.76	62.15	54.24
	19.88	7.66	229.03	86.74	64.41	39.55
9-6-29 8 A. M.	10.81	4.89	114.45	51.76	45.2	30.51
	11.34	5.06	120.44	54.11	45.2	19.21

NOTE.—In Table IV, the upper figures in each case refers to the surface sample. The lower figures has reference to a bottom sample.

Table V shows the results of some determinations made on C-3 on August 19, 1929. This table shows in addition to the dissolved oxygen and phenolphthalein alkalinity also the methyl orange alkalinity, pH and temperatures. The fact of particular interest here is that at 1 P. M. the phenolphthalein alkalinity equalled one-half the methyl orange alkalinity, and at 4 P. M. the methyl orange alkalinity was less than twice the phenolphthalein alkalinity. This means that the algæ had used all the free CO_2, all the bicarbonate CO_2 and some of the CO_2 of the normal carbonate. This means that the alkalinity was due to the normal carbonate and the hydroxide. It had previously been reported by Birge and Juday (1911) that certain algæ used as much as 83% of the half-bound CO_2 and by Wiebe

(1930) that algæ used 92% of the half-bound CO_2. That algæ can use all of the half-bound and some of the bound is in accord with the observation of Neresheimer and Ruttner (1929) that aquatic plants may withdraw small amounts of CO_2 from normal carbonates.

TABLE V.

Table V Shows Dissolved Oxygen, Phenolphthalein Alkalinity, Methyl Orange Alkalinity in Parts per Million, Ph Values and Temperatures in Degrees C. for C-3 on August 19, 1929.

Hour	O_2	Phenolphthalein Alk.	M. O. Alk.	Ph.	Temp.
8:30 A. M.. ...	12.01	40.68	138 99	9 3	20 75
1:00 P. M....	18.25	68 93	137 86	9.5	27 5
4:00 P. M .	27.63	76.84	137 86	9 5	27 5

SUMMARY.

(1) The diurnal variations in dissolved oxygen, phenolphthalein alkalinity, and free ammonia nitrogen have been determined in several instances.

(2) Very marked changes in the actual amount of dissolved oxygen and phenolphthalein alkalinity were observed within a 24-hour period.

(3) The extent of these variations are determined by the abundance of the algæ.

(4) It appears that the algae can utilize all the CO_2 present as the bicarbonate as well as some of the CO_2 of the normal carbonate.

(5) Table IV suggests that the algae may become so abundant as to endanger fish life by depletion of the O_2 during the night.

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A NEW CRUSTACEAN OF THE FAMILY AGLASPIDÆ FROM THE UPPER MISSISSIPPI VALLEY.

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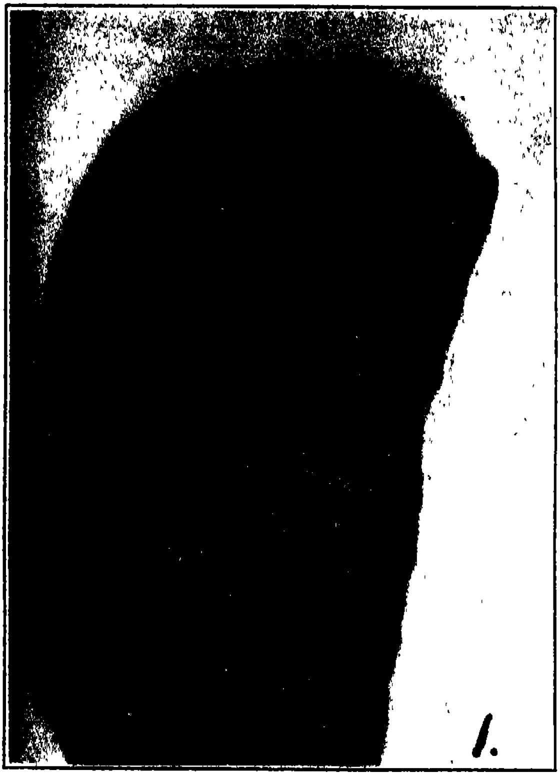
Ohio State University

Aglaspis major n. sp.

DESCRIPTION.—The specimen consists of a very thin portion of the carapace of a large aglaspid in which the left eye is preserved. The specimen consists of a whitish film penetrated by a large number of small openings through which the yellow matrix of the enclosing rock may be seen. The film is thought to be the residue of a test which was perforated by numerous holes. The holes are interpreted as being tangential sections through these perforations.



Aglaspis major Graham.
FIG. 1. Cast of cephalothorax showing eye spot; × 2½.

Cephalothorax apparently broad, with large circular eyes situated near the antero-marginal borders. The eye of the specimen is located on a prominent node from which the surface slopes gradually to the margin of the cephalothorax and steeply toward the mid-line of the head. The eye node rises to a maximum elevation of two millimeters above the general surface. It is eight millimeters long measured parallel to the median line of the head, and nine millimeters wide measured at right angles to the median line. The cephalothorax is perforated by numerous holes or pits which are about one-half millimeter in diameter on the cephalothorax proper and grade down to mere pin points on the border. They are arranged in roughly concentric fashion outward from the eye. The average number of pits per square centimeter is thirty-six, being more numerous on the border area where they are smaller than on the main part of the head. (Figure 1).

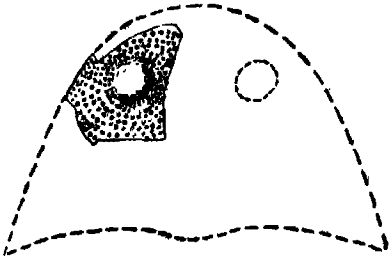


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FIG. 2. Reconstructed cephalothorax, ½ natural size.

REMARKS.

This specimen was found in association with abundant trilobite and brachiopod remains. As far as known it represents the only aglaspid ever found in this locality and the largest one yet discovered in the Croixan of the Upper Mississippi Valley. On the basis of this fragment the head was probably three inches wide and two inches long and the reconstructed animal would probably be from six to eight inches long. (Figure 2).

The specimen resembles somewhat ***Aglaspis eatoni*** Whitfield, but differs by being much larger in size, by having larger, more rounded eyes which are located nearer the margin of the carapace; and in the occurrence of a number of large, strongly marked holes or pits arranged in more or less distinct concentric rings around the eyes.

POSITION AND LOCALITY.

Upper Cambrian (Croixan), Eau Claire sandstone, Cedar Falls, Wisconsin. The specimen was found in a one and one-half to two-inch bed of fine-grained, buff, micaceous sandstone, two and one-half feet above the average level of Red Cedar River, about a quarter of a mile below the dam.

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PRESENT TENDENCIES IN THE PHILOSOPHY OF BIOLOGICAL EVOLUTION.

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I.

Man has been called the problem-solver. This is increasingly true, for as our social organization is becoming more and more complex, new problems are arising and demanding solution. Although most certainly man must be credited with the solution of many vexing problems, his interest far out-strips the limited number of difficulties which his ingenuity has actually been able to meet. The mere contemplation of the formidable array of problems of human as well as mechanical engineering, many of which have arisen in the last century, is bewildering. There is yet so much to be done, and each day brings so many new problems that we often despair of the future and assume that we live in an age the peculiar characteristic of which is its difficult problems. But let us not fall into the error of believing that all of our problems are of recent origin, for some of them, if not many of them, perplexed early man as well as the modern scientist. One such problem is that of the origin and development of life. Darwin, as the uninitiated believe, was not the first to speculate concerning life and its development. The Greeks[1] and even the ancient Egyptians[2] and Babylonians, and the Sumerians and Semites who preceded them, were concerned with this most difficult problem—one of the as yet unsolved problems of our age.

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[1] G. J. Dudycha: "What Is Evolution?", *Scientific Monthly*, 29: 317-332, October, 1929.

[2] G. J. Dudycha: "Ideas of Origin Among the Ancient Egyptians and Babylonians," *Scientific Monthly*, 32: 263-269, March, 1931.

We can not here review that interesting history of the ideas concerning the development of life—a history which covers a period of nearly six thousand years. During this long period many careful thinkers grappled with the problem of how-did-things-come-to-be-what-they-are and each contributed, from his individual point of view and from his meager or intimate knowledge of the phenomena of nature, such ideas and such principles as he thought gave meaning to life. In spite of the fact that numerous solutions have been offered for the problem of development, none has satisfied all the searchers after truth. Yet, there is hope! New views are still being presented and new light is constantly being shed upon the perplexing problem. We are still grappling with the history of life!

II.

In this paper, we shall deal with four outstanding, contemporary ideas concerning biological evolution. The first of these is that of Mr. John Langdon-Davies which appeared as an article in *Harpers* under the title, "The Loves of Orchids."[3]

After a severe criticism of Darwinism, Mr. Langdon-Davies raises the following question for which he supplies the following answer: "How, then, are we to 'save the phenomena'? There is only one way and that is by limiting the power of 'blind chance' and assuming the dominance of 'mind' and memory in all these strange happenings; in believing, in short, that an animal has the organism and uses it in the way it does because it remembers from past experience, when, instead of being itself, it was its ancestors, that just that organism is useful, and just that way of using it is best."[4]

The question which immediately arises in our minds is, What is here meant by the terms "mind" and "memory" and how do they operate so as to promote development? Let us again examine our text and see if we can find an answer. Again I quote. "When the living being is faced with a given situation it behaves as it did when it last found itself in that situation. What happens when it meets a new situation? Either it dies because it can not think of anything to do or it makes some necessary alteration in its organism to meet the new situation. Its offspring remember in their turn what to do and change their organism in the same way, and we have what we call an inherited variation, the product of mind and memory working out sensible solutions to the problems of life. . . . . And to memory must be added the ability to think for itself, that is, to vary and to act upon its thought so far as environment will permit."[6]

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[3] J. Langdon-Davies: "The Loves of Orchids," *Harpers*, 160: 374–381, February, 1930.

[4] J. Langdon-Davies: *loc. cit.*, p. 380.

Now that we have the essential ideas of Mr. Langdon-Davies in mind, let us consider them critically. First, what does he mean by "memory?" This term is sometimes given two meanings, the one, biological and the other, psychological. From the point of view of biology, a modification which is made, perpetuated and inherited is said to be remembered. In this concept consciousness is not present. If this is what the writer of, "The Loves of Orchids" means, then we can raise no objection, but does he? From the psychological point of view, memory refers to a conscious process—the consciousness that a present experience is more or less intimately related to an experience in the past. Is this what Mr. Langdon-Davies means by memory? We may suspect that it is when we recall the statement: "Either it dies because it can not think of anything to do or it makes some necessary alteration in its organism to meet the new situation." The significant word here is "think." If thought is a conscious process, as we know it to be, and if orchids are capable of exercising thought, then their memory is also very likely conscious. If this is true, then perception would also seem to be a necessary characteristic of the orchids. In the end, it seems, we have been quite successful at personifying the orchids. Also we must note that memory in the psychological sense does not merely imply retention, as the biological use of the term does, but recall and recognition. It is not merely the retention of a modification made at some time in the past, but the ability on the part of that individual to consciously relate that modification or experience to the present. Is this what is done by the orchid, by the protozoan, and shall we be so bold as to say, by the star?

There is a second problem which we must consider. Mr. Langdon-Davies tells us that the orchid "makes some necessary alteration in its organism to meet the new situation" and that the "offspring remember" this change and thus make the corresponding change in their organisms. Thus we have an "inherited variation." But again this raises a number of difficulties. Out of all the possible modifications, how is the particular initial modification effected? By taking thought! According to the language of the author of "The Loves of Orchids," the orchid must take cognizance of its problem—it perceives the problem, appreciates the need for its solution and "thinks" out a way of escape. The offspring "remember" the profound solution of the parent and ergo, we have an inherited modification in spite of the fact that not even man can add one cubit to his stature by taking thought. It is just this thought process that we would like to know more about, but unfortunately, we are told nothing about its nature.

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[6] *Ibid*, p. 381.

The last problem to which we must call attention is the problem of mind. Although Mr. Langdon-Davies tells us that we shall probably have to change our notion of mind, he does not offer to define it for us and thus we are left with the unanswered question, What is mind? If the writer of our text, conceives mind as the force or drive which is responsible for the activity of the creative, developmental process, then another problem looms into view, namely, the problem of distinguishing mind as the go-of-events from mind as the end-result or emergent. From the way he uses the term mind we are led to believe that he is trying to use mind—the end-result, product or emergent—as the drive in all development. This does not seem possible for mind, as he uses it, is itself a resultant. Although there most certainly are formative forces, the term mind should be reserved to designate the end-product, the result, the fruition of the creative process. If the meaning and the use of the term mind were definitely designated, some of our difficulties in understanding this point of view of development would be eliminated.

We had anticipated that after understanding Mr. Langdon-Davies' point of view of development we would have the answer to his question, "How shall we save the phenomena?" But now that we have examined his ideas carefully and critically, we are disappointed. We expected an answer to our problem, but instead we discovered new problems. But let us continue our search for an answer to the problem of how-did-things-come-to-be-what-they-are. Since we have merely considered the first of our four points of view, let us turn to a careful consideration of the second.

III.

Dr. Austin H. Clark, who has labeled his point of view "Zoogenesis,"[6] begins with two assumptions: (1) only life begets life, (2) all living things begin their life as a single cell in which there is not any discernible trace of the adult form. Thus in order to discover the order in the living world, we begin, first, with the idea of the continuity of life from its origin down to the present, and second, with the idea of the common origin of all life in the primitive single cell. Thus all life must have come from this primitive cell by some process. What was the nature of this process? Dr. Clark tells us, "that from the primitive single cell there *simultaneously*[7] appeared through mutation as many different types of animals as were capable of successful existence."[8] And thus, "all of the major groups of animals were formed at the same time as the result of following different developmental paths from the primitive single cell."[9] In support of this contention, he draws his evidence from embryology. "The several major groups exhibit a great variety of conditions in the relation of their different balance in their various essential organs. In their embryonic stages the representatives of the various major groups show a close approximation to each other in the gastrula, but are wholly similar to each other only in the germ cell."[10] To this first phase—simultaneous appearance of all the phyla from the primitive cell by mutation—of his point of view, Dr. Clark gives the name "eogenesis."

Since "we are forced to the conclusion that all the major groups of animals at the very first held just about the same relation to each other that they do today," we must also assume *concurrent evolution*. Thus the ground is prepared through eogenesis, but the growth of the trees—the phyla—is known as evolution. We have, then, the introduction of a second term, that is, *evolution* which is not used to designate a single process, but the individual history of each type of life. Thus we have as many evolutions, all of which are running concurrently, as we have types of life.

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[6] A. H. Clark: *The New Evolution Zoogenesis*. Baltimore: Williams and Wilkins, 1930.

A. H. Clark: "Zoogenesis: the New Theory of Evolution," *Scientific American*, 143 (2): 104–107, August, 1930.

[7] Italics are mine.

[8] A. H. Clark: *The New Evolution Zoogenesis*, p. 220.

[9] *Ibid*, p. 212.

[10] *Ibid*, p. 216.

Yet a third question presents itself: How do animals change their form? For this there are three things necessary: first, there must be the production of variants or mutants; second, these variant characters must be heritable; third, the mutants with their heritable characters must be capable of meeting the conditions under which they live to such an extent that their kind is perpetuated. Since specialization is a function of progressive subtraction, the more remote the particular manifestation of life is from the primitive type the less the possibility of producing extensive mutants which vary greatly from the parent type. Thus, "the primitive single cell, having within the potentiality for the production of all types of animals, might be assumed to be possessed of the ability to produce simultaneously mutants which would be widely different from each other, both by structural changes in the single cell and through development involving cell multiplication in various directions."[11]

We see, then, that the process which results in the simultaneous appearance of all types of life is known as eogenesis; the development of many animal forms from the single original type is known as evolution; and the process by which new forms appear is known as mutation. Life is not to be thought of as a single tree with its branches arising from a common trunk, but as a forest of trees each of which has its roots in the soil prepared by eogenesis.

Although the above description of this second point of view might be greatly elaborated, we have Dr. Clark's essential thesis. Let us, then, examine it more carefully. A number of questions arise in our minds. What does he mean by *simultaneous* appearance of all types of life? What are the conditions which were responsible for the simultaneous appearance? What was potential in the primitive cell? Let us return to the first question. What is meant by "simultaneous"? Are we to understand that all types of life appeared from the single cell at the same instant, or that all appeared at some time during pre-Cambrian times? Again we ask, Did all the types of life come from a single cell, or from primitive cells, or did some separate later from the gastrula? If we shall return to our text, we shall find the following statment: "The only possible conclusion is that there is not now, and there never has been at any time in the past, any linear relationship between the major groups of animals at any stage later than the gastrula."[12] This seems to indicate, as we also find in the figure on page 246, that some of the phyla had their origin in the gastrula, which is a later development from the primitive cell, and not directly in the primitive cell itself. Thus we find that our notion of what is meant by "simultaneous appearance" is vague.

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[11] *ibid*, p. 220.

The second question which we raised was concerning the nature of the conditions which gave rise to the simultaneous appearance of all the phyla. It is difficult for us to imagine how certain conditions, obtaining at this early time, could be responsible for the sudden appearance of numerous types differing widely, and then not continue to produce additional types. In other words, why did the whole thing occur once and for all and never again? It seems that Dr. Clark would have us believe that the original diversification of life was cataclysmic and not gradual as it seems to have been subsequently.

There is yet another objection which we must note. Paleontology, as Dr. Matthew[13] points out, does not warrant Dr. Clark's conclusion concerning concurrent development from the original appearance of all of the types of life. Although it is fairly evident that there are various independent lines of development, which have been more or less parallel, since Cambrian times, it does not follow that they were equally independent in pre-Cambrian times. We must admit that our knowledge of the history of life in pre-Cambrian times is very sketchy and incomplete, but what little is known does not seem to point in the direction of Dr. Clark's thesis. It is probable that the laws of nature, which we observe are operating now, operated then, and that all the types of life did not appear suddenly and miraculously.

We have examined *Zoogenesis* and have found that it too is wanting. We had hoped that we would find a solution to the problem of the development of life, but instead we are faced with more questions. We are not ready, however, to give up our quest. Let us turn to our third point of view.

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[12] *ibid*, p. 248.

[13] W. D. Matthew: "The Pattern of Evolution," *Scientific American*, 143: 192–196, September, 1930.

IV.

Professor H. J. Muller,[14] who in a recent article entitled "The Method of Evolution" discussed some of the results which he has obtained from his noteworthy experiments on the fruit-fly, *Drosophila*, makes a very interesting suggestion which may throw light upon our problem. He has found that by treating the fruit-fly, *Drosophila*, with X-rays a large variety of mutants, some of which have favorable and others unfavorable characteristics, may be produced. In addition to X-rays, he believes that radium rays, gamma rays and cosmic rays affect organisms in a similar way and thus produce variations. With this idea in mind he draws the following conclusion: "This being true, there being no evidence of a minimal or 'threshold' dosage, we are forced to conclude that the minute amounts of natural radiation present almost everywhere in nature—some of it of terrestial origin, derived from the radium and other radioactive substances in the earth, water and air, and a smaller part of it of cosmic origin, apparently derived from the diffuse and distant factories of matter—all this natural radiation *must* be producing some mutations in the living things on the earth. These mutations must be very scattered and very infrequent in proportion to the total non-mutated population, just because the amount of natural short-wave-length radiation is very small at any one place, but, considering the extent of the earth and the multiplicity of living things, the total number of mutations so produced per year must be very considerable. It can, therefore, scarcely be denied that in this factor we have found at least *one* of the natural causes of mutation, and hence of evolution."[15]

Recently attempts have been made to test this hypothesis that radiations of the earth cause mutations in genes. As the result of experiments, it has been found that fruit-flies, which were reared in a tunnel in the mountains where radiation was strong, produced more mutations than were produced in the laboratory where radiations were weak. We must note, however, that not only do radiations of the earth affect the rate of the appearance of mutations; but also that temperature, as has been pointed out by Professor Muller, determines their rate of appearance in much the same way that temperature speeds-up a chemical reaction. In view of this, Dr. Davenport says:

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[14] H. J. Muller: "The Method of Evolution," *Scientific Monthly*, 29: 481–505, December, 1929.

[15] H. J. Muller: *loc. cit.*, p. 496.

"Also, it seems probable that radiations are not the primary cause of gene mutations but that they accelerate processes that are initiated by the internal structure of the genes.

"That the essential nature of gene mutation is determined primarily by internal conditions is well shown by the experiments of Demerec. . . The gene has internal capacity for mutation just as an alarm clock has an internal mechanism for ringing a bell at a particular time. Gene mutation can arise from the very mechanism of the gene."[16]

Apparently, then, according to Davenport, the real cause of mutation is in the very nature of the gene and X-rays or the related waves of shorter wave-length, as gamma and cosmic rays, are merely conditions which hasten the process.

No doubt, Muller would refute this objection by pointing out that the powerful rays which affect the gene cause changes there-in which lead to its reorganization. He says: "For the electron, shot out like a bullet (except far faster), tears its path through thousands of atoms that happen to lie in its way, leaving in its wake a trail of havoc before it is finally stopped. In this process, many of the atoms through which the electron tears have one or more of their own electrons torn out or dislodged from their proper places; this change in the structure of the atoms often causes them to undergo new chemical unions or disunions that in turn alter the composition of the molecules in which the atoms lay. If a gene is a molecule, then, with properties depending upon its chemical composition, it can be shot and altered by the electrons resulting from the absorption of X-rays or rays of shorter wave-length."[17]

Here, then, we find in Muller's conception of cosmic energy as the cause of the process of development *one* of the possible methods of development. Since his conclusions are based upon extensive laboratory studies rather than upon pure speculation, and since they do seem to be so highly suggestive, we are greatly inclined to believe that perhaps we have found here something significant, and that some light is being shed upon our difficult problem.

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[16] C. B. Davenport: "Light Thrown by Genetics on Evolution and Development," *Scientific Monthly*, 30: 307–314, April, 1930.

[17] H. J. Muller: *loc. cit.*, p. 491.

V.

The last point of view concerning the possible methods of development which we are to consider is that of a cytologist. Dr. Philip R. White in his recent article, "A Disease and Evolution,"[18] points out that hybridization is most certainly one of the methods of evolution. Due to the extensive losses which have been sustained on the banana plantations which have been caused by the ravages of the "Panama disease," Dr. White studied Gros Michel, our edible banana, with the idea that immunity might be produced by hybridization. If one of the parents is immune, he reasoned, why could immunity not be produced by breeding the parent again? Thus the first problem was to discover the parents of Gros Michel. After a careful examination of the nuclei of the cells of the banana, he found that each contains thirty-two chromosomes which, of course, should give at syndesis, if the parentage has been proper, sixteen pairs. This, however, did not happen for only twelve pairs were observed and eight extras which were scattered and unattached. Thus when the daughter cells were formed these eight extras were often unevenly distributed. Since this is true, the question is, Who are the possible parents of Gros Michel?

Because of what happens at syndesis in the banana, it seems quite apparent that it received twelve chromosomes from the one parent and twenty from the other, which thus gave rise to the twelve pairs and eight extras. Since each parent, except in unusual cases, contributes one-half of its chromosomes to its off-spring, one of the parents of the banana must have had twenty-four chromosomes and the other forty, unless, for some unknown reason, one of the parents contributed all of its chromosomes. With this assumption, Dr. White proceeded to look for the possible parents of Gros Michel and as the result of an extensive search found 38 individuals with twenty-four chromosomes, two with twenty, one with twelve and a single forty. In addition to these possible parents of the banana, Dr. White studied 108 other varieties all of which were discarded. Although he did not find definitely which of the possible parents of Gros Michel were the actual parents, he did make one very significant observation, that is, that we have here in the banana a polyploid series the basic number of which is eight and that all of the 150 varieties studied, whose chromosomes range from twelve to forty-eight in number, may be accounted for by some process of combination and hybridization which began with the original banana with eight chromosomes.

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[18] P. R. White: "A Disease and Evolution," *Scientific Monthly*, 31: 306–318, October, 1930.

Thus we have here another "method" of evolution presented. "In a recent issue of this journal," says Dr. White,[19] "there appeared a paper by Professor H. J. Muller entitled 'The Method of Evolution.' I should prefer that he had entitled it 'A Method of Evolution,' for though the evidence of the existence of mutations is unquestionable and the evidence for the activity of cosmic and earth rays in producing these mutations grows from day to day so that I should certainly not concur with Professor Jeffrey in ridiculing this method, I nevertheless feel that the evidence for concomitant evolution by hybridization is even better established, and that, while perhaps it is not so fundamental in scope as is the 'ray' evolution, it has played a much more obvious and far-reaching role than has the former. This polyploid genealogy is not an isolated example but is typical of whole family groups and also occurs (perhaps of a different origin?) in Professor Muller's own fruit-flies."

Here, then, we have another highly suggestive point of view, based upon extensive experimentation and research, which can not be readily refuted. Thus we see that Dr. White in emphasizing that the changing pattern of life is due to the changing pattern within the cells, which results from particular kinds of combinations, has shed more light upon our vexing problem.

VI.

Now that we have considered four contemporary points of view concerning biological evolution, we come to grips with the problem of development itself. Mr. Langdon-Davies, we found, posited mind and memory as the two important factors responsible for the progressive development in the history of life; but he failed to tell us how these two factors operated, let alone what they are. To merely say that a plant or an animal in the presence of a given difficult situation thinks out a way of escape and that its off-spring remember its solution tells us nothing. We do not know why the organism thinks, how it thinks or for what reason it remembers. We merely have two words "mind" and "memory"—magic words—which have worked a potent charm and thus we have all the various forms of life. This view of things is certainly not satisfying, nor is it particularly new. Mind has too long been invoked as a mysterious *cause* of things.

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[19] P. R. White: *loc. cit.*, p. 318.

Zoogenesis, we have also found, is but little better than the first point of view which we considered. By some mysterious means all the types of life burst forth simultaneously from the primitive single cell. There certainly is no conclusive evidence that such a thing ever did occur, nor can we comprehend how it could have been the case since that has quite apparently not been the method of nature during historic times. Again we find in Zoogenesis the idea of the potentiality of all things in the primitive cell. "The single cell has inherent in itself the potentiality for development, through selective and progressive reduction in various directions and in various ways, into every form of life which at any time may be capable of existence and of self-perpetuation under the conditions obtaining at that time.

"All animal types are therefore to be regarded, in their relation to cosmic evolution, simply as varied and varying manifestations of the inherent potentialities of the fundamental substance protoplasm. Such a concept contemplates the animal world as in reality but a single unit finding its expression in an infinity of equations all of which, no matter how complicated they may seem, reduce themselves to the same fundamental term."[30]

This by no means is a new idea for St. Augustine expressed essentially the same idea centuries ago. Putting Augustine's idea in modern terms: "In the beginning God made" the first single cell—germ or seed—in which all things that are found in the world today were implicit, and by a process, governed by natural laws with which the Creator endowed this first piece of matter, have become and are becoming explicit. The first cell was the potential universe with all things that are found therein. But Augustine's idea is no longer tenable; it is not adequate as a philosophy of development.

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[30] A. H. Clark: *loc. cit.*, p. 216.

Hence Zoogenesis is also inadequate. It may appear to be serviceable when one is dealing with the development of life, although we have found difficulties even here; but it is wholly inadeqate when one deals with the whole of development of which biological evolution is merely one phase. Hence Zoogenesis has but little to offer us for a philosophy of development.

The last two methods of evolution which we considered—that of cosmic radiation as the cause of development, and hybridization—are the most significant for the philosophy of evolution. In order to have a process we must have a drive of some kind which is the go-of-events. This drive has been variously termed by philosophers—vital urge, *elan vital*, nisus, etc. Perhaps we might be so bold as to include cosmic radiation, but this is still somewhat hazardous. Although we may quite readily see that cosmic rays are at least one of the causes of biological evolution, it is not so easy to see the relationship between this short-wave-length radiation and other more extensive aspects of the development of the universe. There may, however, be a significant relationship which only future study will reveal. On the other hand, hybridization is directly in accord with one of the outstanding present-day philosophical concepts of development—namely, *emergent evolution*. An hybrid is an emergent. Professor Nabours[21] says:

"It has long been known, and is every day becoming more obvious, that sexually reproducing organisms, including man, are generally heterogeneous (we now know not exclusively heterozygous) for a wide range of genes. It has also been ascertained that each discrete characteristic is due to the interactions of several or many different genes, whether in heterzygous or homozygous doses, or distributed over one or more pairs of chromosomes. This fact having been well established and universally acceded to by geneticists, it may, with good reason, be suggested that such characteristics are not merely the additive sums, mosaics, or resultant combinations of the activities of the respective genes, but they are emergences in the same sense that ethyl alcohol and ether are emergences of the respective syntheses of the elements hydrogen, carbon and oxygen."

Thus we have here an idea concerning the method of development which is not only serviceable in biology, but one which is also in accord with a more general process which includes many other aspects of the universe than merely life.

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[21] R. K. Nabours: "Hybrid Emergence," *Eugenical News*, 15, July, 1930.

When we are dealing with biological development, we can not avoid turning our attention to the broader aspects of development, to cosmic evolution. As the careful thinker directs his attention away from his immediate surroundings to the infinite spaces, and contemplates the nature of the universe with its gigantic, heavenly bodies moving at incredible speeds, and with its vast interstellar spaces, its detailed organization and perfection in operation, he asks, "What is man?" But then, courage rises for not only that brightly beaming star and yonder planet, but man and even the lone daisy in the grass, all are a part of this vast and intricate system. Truly it is a *universe!* This being true, there must be some cosmic process—a single process—which is not only responsible for the suns and our earth, but also for the atom, the molecule, the crystal, the organism and for society with all its ramifications. The most apparent difficulty in the history of thought concerning evolution is that too many thinkers—profound thinkers—are interested in but a limited portion of the universe—life. They have propounded many theories of biological evolution, which often appear to be adequate concerning the development of life, but which can not be stretched to fit the universe. No theory of biological development is adequate unless it is in accord with the more general aspects of cosmic evolution.

THE ALIMENTARY CANAL OF MERACANTHA CONTRACTA BEAUV. (TENEBRIONIDÆ).*

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INTRODUCTION.

The Tenebrionid beetle, *Meracantha contracta* Beauv., is a medium sized (11-13 mm.), ovate and strongly convex species. It is wingless and especially distinguished by having the head received in the thorax nearly to the eyes. It occurs east of the Mississippi River and is very abundant in the oak and maple forests of the northern part of Ohio.

The problem of making an anatomical study of the alimentary canal of this species was suggested because of the availability of specimens and their interesting bark eating habits. The specimens used for this study were collected at Put-in-Bay, Ohio, from the trees found on the northern border of South Bass Island.

The process of preparation was as follows: The specimens were chloroformed, the elytra cut off and then the abdomens of some slit open dorsally, of others ventrally, before being fixed in Carl's fluid and preserved in 80% alcohol.

Upon dissection of the specimens it was discovered that in many cases an improvement could have been secured by a more extensive opening of the body, especially through the thorax and head. This would have allowed a much quicker penetration of the tissue of the anterior end of the mid-gut and the fore-gut as the heavy chitin surrounding this region slowed down the action of the fixative thus causing some tissue disintegration before complete permeation was reached. The fore-gut especially was very inaccessible, as it was found to be confined to the head and of necessity therefore, extremely short.

Due to the heavy intima of chitin in the fore- and hind-guts, it was found necessary in sectioning to pay particular attention to keeping the edge of the microtome knife sharp as there was a constant tendency for these sections to crush and tear. Most of the sections were cut 8 microns in thickness and gave good results in staining.

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*Contribution from the Department of Zoology and Entomology, Ohio State University, No. 106.

The ordinary double staining process with Delafield's Hematoxylin and Eosin was used in the preparation of slides.

The drawings were made with the aid of a camera lucida.

The author desires to express his sincere appreciation for the helpful suggestions and criticisms of Doctor C. H. Kennedy, under whose guidance and direction this work was undertaken.

GENERAL DESCRIPTION.

Strictly speaking the alimentary canal is a rather simple tube extending from one end of the insect to the other. In the case of the beetle under discussion, which is a phytophagus or plant eater, it is of medium length extending in a nearly median line (Figs. 1-2) from the mouth parts back to the beginning of the abdomen where it curves slightly to the right down as far as the third segment, where it curves to the left and comes up to the first segment close to the edge of the body cavity and near the dorsal surface. It is then angulated and again approaches the median line just anterior to the first segment and then passing over itself in the second and third abdominal segments. It is thus nearly half again as long as the entire body.

Meracantha contracta, as is generally true of all insects, has three primary divisions of the alimentary canal present (Fig. 3); the stomodium or fore-gut, the mesenteron or mid-gut and the proctodeum or hind-gut.

The conditions concerning the attachments of the canal in the body are the same as in all insects: the fore-gut and hind-gut are invaginations of the ectoderm and therefore the body wall is, of necessity, continuous with the alimentary canal at both extremities. It is also supported by tracheæ along its entire length, as these support the gonads and fat-body, which in turn form a supporting sheath about the canal. Also there are certain suspensory muscles attached to the dorsal wall.

In origin, the fore-gut and hind-gut, as mentioned in the preceding paragraph, arise as invaginations of the body wall, and thus are ectodermal in origin. The mesenteron, however, has an altogether different history as it is formed by the proliferation of rings of endodermal cells, one around the inner end of the fore-gut and the other around the inner end of the hind-gut. The endodermal cells form the digestive epithelium and all muscles, tracheæ and connective tissue concerned with the canal are of mesodermal origin.

Thus two important features of the canal will be observed; first, that the fore-gut and hind-gut being ectodermal in origin, resemble the body wall in structure, and second, that the mid-gut being mesodermal in origin, presents a marked difference, histologically, from either the fore-gut or hind-gut.

The gross parts of the canal of *Meracantha contracta*, can be listed as follows:

1. The mouth, the part opening to the exterior, located in the head and concerned with the mouth parts.
2. The pharynx, the region just distal to the mouth.
3. The oesophagus, the first and most simple part of the throat tube.
4. (No crop is evident because of the extreme shortness of the entire fore-gut, which extends only the distance through the head.)
5. The gizzard or proventriculus, the lower end of the oesophagus having a much thickened chitinous intima, thrown into many folds and surrounded by prominent circular muscles.
6. The oesophageal valve (cardiac valve); this is situated at the union of the fore-gut and mid-gut and acts as a valve below the gizzard, preventing regurgitation.
7. The stomach or mid-gut; this is the digestive part of the canal.
8. The pyloric valve; this is located at the union of the mid-gut and hind-gut.
9. The Malpighian tubules; these are six in number and are attached to the canal just posterior to the pyloric valve.
10. The hind-gut; this is the third primary division of the canal and is further subdivided into:
    - A. The small intestine or ileum, the small angulated part of the hind-gut posterior to the pyloric valve.
    - B. The large intestine or colon, the larger and somewhat thinner walled part of the hind-gut posterior to the ileum.
    - C. The rectum, a short funnel-shaped organ, connecting the colon and the exterior of the body.
    - D. The anus, the aperture connecting the rectum and the exterior of the body.

Each of these divisions will be described under the subject, "The Histology of the Canal."

The Histology of the Structure of the Alimentary Canal.

THE FORE-GUT OR STOMODEUM.

In *Meracantha contracta* this portion of the canal is confined entirely to the region of the head (Fig. 4), the union with the mid-gut taking place at the posterior opening in the head, which is slightly larger than the anterior end of the mid-gut. By actual measurement the fore-gut only averages two millimeters in length.

A longitudinal section through the head discloses that there is a definite adaptation to the bark-eating habit. Below the labrum or upper lip, which is slightly flexible, a pair of strong-toothed mandibles extend well back into the head, where powerful muscles operating them are attached to the posterior walls. The mandibles work from side to side and each possesses at its posterior end, on the inner surface, a heavily chitinized plate known as a molar or crushing surface. Anterior to these plates are areas of thinner chitin, and from the floor of the mouth, slightly in front of the plates arises a hypo-pharynx or tongue-like structure which is connected with the posterior end of the labium or lower lip. The posterior part of the mouth cavity is large and narrows down where it joins the anterior end of the fore-gut. (Fig. 4).

The pharynx extends from the mouth cavity to about where the tube is encircled by the large and prominent brain ganglia. The intima of the pharynx as well as that of the rest of the fore-gut, is armed with small backward directed spines, arising from small punctures or invaginations in the intima.

The oesophagus is very short and widens out considerably in a funnel shape before joining the mid-gut. The lower portion of the oesophagus has a prominent thickening of the chitinous intima which is much ridged in nature. This portion is known as the proventriculus or gizzard, (Fig. 6). No evidence of a crop is seen due to the extreme shortness of the fore-gut and probably little or no digestive action occurs while the food is passing through the fore-gut. No evidences of salivary glands were observed. Histologically, as a rule, the following layers, from within outwards, can be recognized. First, the intima or intermost lining, which takes the form of a chitinous layer, directly continuous with the body wall. Second, the epithelial layer, continuous with the hypodermis and chitogenous in function. Third, the basement membrane bounding the outer surface of the epithelium. Fourth, the longitudinal muscles. Fifth, the circular muscles. Sixth, occasionally the peritoneal membrane, a structureless connective tissue composed of very thin cells and difficult of detection.

Examination of a cross section through the fore-gut of *Meracantha contracta*, (Fig. 5) shows a well-developed intima consisting of a thick layer of chitin, armed with spines, the primary cuticula. This is backed by a variable region of chitin, the secondary cuticula. Next to the intima occur the rather large cuboidal epithelial cells. These vary somewhat in size but all contain large oval nuclei densely filled with coarse deep-staining chromatin granules.

The basement membrane is not clearly differentiated, but this is probably due to the action of the fixative. The longitudinal muscles occur within the circular muscles, lying in strands at irregular intervals. They continue throughout the fore-gut and pass on into the mid-gut.

The longitudinal muscles are continuous with the mid-gut and divide into several strands just before reaching the point of extension into the mid-gut. Some of these continue down into the folds of the valves while the rest pass between the circular fibers and cut abruptly across to the surface of the mid-gut where they continue throughout its extremity. (Fig. 6).

The circular muscles are very strongly developed, forming a continuous layer over three times the width of the epithelial tissue. They are clearly striated, with many nuclei present. They appear to have developed in accordance with the effort required to force the bark particles eaten, down into the proventriculus.

The peritoneal membrane, if present, is not capable of detection.

THE UNION OF THE FORE-GUT AND MID-GUT.

At the point of union between the fore-gut and the mid-gut, a structure is present which is known as the oesophageal or cardiac valve. It is formed by a fold of the fore-gut extending down into the mid-gut. This then becomes reflected upon itself and passes forward to unite with the wall of the mid-gut. (Fig. 6).

The histological structure of the valve, discloses that the intima disappears at the end of the fore-gut, where there is a well-marked change in the character of the epithelium. These epithelial cells, in the fold, gradually change from a cuboidal shape into narrower and more elongate cells with their nuclei at the tips, thus they appear at the periphery of the curve in the fold.

Where the intima ceases, the epithelium has assumed the characteristic elongated type of the mid-gut, although there is a marked shortening in a few cells just preceding, due to the abrupt curve and impingement against the circular muscles.

A well-marked ring of circular muscles appears within the interior of the fold, which acts as a sphinctor, allowing the valve to be closed.

The longitudinal muscles are represented in the valve by only a few scattered strands extending down from the fore-gut.

The valve appears from a ventral view, as a number of flaps or folds, which when drawn together by the circular muscles, in much the same manner as a meal sack, fit together in such a way as to completely close the orifice and prevent any regurgitation of food. (Fig. 7).

THE MID-GUT OR MESENTERON.

This portion of the alimentary canal in *Meracantha* extends from the posterior part of the head to the third abdominal segment where it curves to the left and up to the first segment. (Fig 3). Its great size in comparison with the rest of the tract is very striking. In addition, the ringed or segmented appearance of the gut is noticeable. This condition is due to the position of the gut circular muscles which are gathered together in bundles at intervals, and cause constrictions in the surface, that appear as rings about the gut.

The longitudinal muscles continue from the fore-gut down the mid-gut, crossing over the union of the two guts in distinctive bundles that give the anterior end of the mid-gut a constricted appearance at intervals. (Fig. 8). These constrictions are at right angles to the circular constrictions. The fibers then diverge and course along the mid-gut crossing the circular muscles at approximately right angles. Thus the whole surface presents a plaid-like appearance. The muscle fibers apparently do not inter-branch to any great extent, but are densely interwoven by very small tracheoles which run throughout the whole surface in very irregular fashion. (Fig. 9). Scattered at frequent intervals between the so-called bundles of circular muscles are isolated circular muscles.

The layers of the wall of the mid-gut are, from the inside out, as follows:

First, the digestive epithelium of endodermal cells.

Second, the basement membrane.

Third, the circular muscles.

Fourth, the longitudinal muscles.

Fifth, the peritoneal membrane which is not discernible in the slides prepared in this study.

The limits of the mid-gut are marked anteriorly by the oesophageal valve and posteriorly by the Malpighian tubules. Examination of a cross section through the mid-gut (Fig. 10) shows the epithelium to be composed of columnar cells, which vary considerably in length, size and shape, probably due to the physiological condition they happen to be in at the time. The majority of the cells however, are long and narrow and contain large median and ovate nuclei densely filled with coarse chromatin granules. Toward the outer margin of the cells, the nuclei gradually fade out. Scattered irregularly along at the bases of the cells are replacement cells pushing up from the nidi or nests of new cells. These cells are somewhat triangular in shape and wedged in between two of the larger cells, which, gorged with digestive secretions, burst into the lumen of the gut. Secretion is thus holocrine as the ruptured ends of the cells indicate. A striated border if present is obliterated by the broken and ruptured ends of the cells, as the insects were fixed at a time when the mid-gut was gorged with food and the process of digestion active.

A peritrophic membrane is present in the lumen, which protects the delicate epithelial tissue from the action of the coarse bark particles. This is probably secreted by the epithelial cells in general as there is no evidence of any specialized cells at the extreme fore end of the gut as found in some insects. In fact the membrane does not make its appearance until some distance back of the anterior end.

The basement membrane is present at certain portions of the cross section and probably would be evident throughout, if the action of the fixative had been quick enough.

Both circular and longitudinal muscles are striated, with numerous nuclei present, and their respective relation to each other in regard to position is the reverse from that found in the fore-gut, namely, the longitudinals being exterior to the circulars. The two layers interchange positions at the oesophageal valve, where the fibers interlace as previously described. (Fig. 6).

The connective tissue containing the muscles and surrounding the exterior of the canal is plainly evident.

No evidence was obtained of any differentiation between digestive and absorptive cells, probably they possess a double function which is characteristic throughout the mid-gut. The digestive epithelium terminates abruptly where the Malpighian tubules enter the canal, being followed immediately by the epithelium of the intestine or hind-gut.

THE UNION OF THE MID-GUT AND HIND-GUT.

THE PYLORIC VALVE.

In *Meracantha contracta* there is a definite pyloric valve which however, probably does not function in closing the gut as the fecal matter enclosed within the peritrophic membrane keeps the region of the valve widely distended.

In structure the form of the valve is very similar to the oesophageal valve, although there is not the gradual change in cell structure, (Fig. 11). Enclosed within the fold of cells is a definite group of circular muscles, with a few scattered strands of longitudinal muscles. The intima of the hind-gut where the valve commences, makes a gradual curve into the lumen for a short distance, then a sharp curve folding back upon itself before extending back into the gut, the epithelial cells abruptly shortening. Thus the portion of the wall called the valve is very little thicker than the wall at any other point. There is thus no impediment offered as the fecal matter is forced out of the fore-gut into the hind-gut.

THE HIND-GUT.

This is called the proctodeum and includes all of the intestine from the stomach or mid-gut to the anus.

Histologically, the layers of the wall of the hind-gut are, from within outwards, as follows:

First, the intima.
Second, the epithelium.
Third, the basement membrane.
Fourth, the inner circular muscles.
Fifth, the longitudinal muscle strands.

Sometimes there is present in some insects a layer of outer circular muscles and also a "peritoneal membrane" of connective tissue cells. These last two are lacking in *Meracantha contracta*.

The intima or chitinous lining is secreted by the epithelium which is invaginated body wall and has the same general characteristics as the hypodermis.

The epithelium is identical with the hypodermis of the body wall and is for the most part composed of cuboidal-shaped cells.

The basement membrane is indistinct throughout the hind-gut.

The inner circular muscles are a distinctive layer.

The longitudinal muscles are present and grouped for the most part into large bands.

Three well-marked regions are recognizable in the hind-gut: the small intestine or ileum, the large intestine or colon, and the rectum, (Fig. 3). These will be discussed in order.

THE ILEUM.

This region comprises about one-third of the total length of the hind-gut and is rather convoluted in the region of the first abdominal segment. It enlarges into the division called the colon at the point where the Malpighian tubules become attached to the surface of the gut.

The primary intima of this region is rather thin but the secondary intima is quite thick. The epithelium is composed of cuboidal-shaped cells and thrown into folds, six seeming to be the average. The cells are distinct in the anterior part of the gut, but tend to become less distinct posteriorly. The nuclei are large and prominent.

The circular muscles are well developed throughout the region. The longitudinal muscles lying outside of the circulars, are scattered at irregular intervals over the ileum.

The basement membrane is indistinct, both throughout the ileum and the colon as well.

THE COLON.

There is no abrupt transition, between this region and the one preceding as the epithelium changes gradually in appearance The primary intima becomes somewhat thicker, with the secondary still very evident.

However, a new set of longitudinal muscles makes its appearance, outside of the circular muscles, being definitely grouped in six bands. These become larger and thicker as they approach the rectum. The spaces between the bands are evenly distributed and each contains a Malpighian tubule. Connective tissue closely holds the Malpighian tubules in place. (Fig 12).

The circular muscles are well developed at the anterior end of the colon, but gradually disappear until only a few fibers are left near the posterior end.

As the course of the colon is observed towards the rectum, the epithelial cells become more and more flattened, and their boundaries become less distinct. Their protuberances into the lumen of the gut are irregular and give a distinctive wavy appearance to the intima.

THE RECTUM.

This region, similar to a cone in appearance, the narrow end terminating in the oval aperture, is characterized chiefly by its very abrupt union with the colon, (Fig. 13). A great enlargement of new circular muscle fibers make their appearance here and probably act as an intestinal valve. The sphinctor being thus formed, is much more developed than the one formed at the pyloric valve, hence this probably takes its place in function.

The circular muscles gradually decrease in number and thickness as the oval aperture is approached. The longitudinal muscles disappear entirely.

The intima at first is quite smooth but soon forms many folds which posteriorly become very pronounced, and somewhat tooth-like in appearance. Ordinarily these so-called "teeth" or rectal pads (Fig. 15) are six in number but in the case under discussion there is a marked irregularity. They probably vary in number from four to seven or eight, (Fig. 14).

At the anterior end of the rectum, the intima forms a bulge out into the body cavity. This evidently facilitates the attachment of the muscles of the colon and the origin of those in the rectum as well.

The epithelial cells are much smaller than those in the colon while the divisions between them are more pronounced. The nuclei are relatively large and contain large granular masses.

The chitinous spines as observed in the fore-gut are entirely lacking in the rectum as well as in the hind-gut in general.

THE MALPIGHIAN TUBULES.

These vessels are ectodermal in origin and therefore should be associated with the hind-gut. Their function is primarily urinary. Upon sectioning and staining the tubules, deposits of concretions are found scattered throughout the epithelium. These are probably depositions of such end products as uric acid, urates, etc.

In *Meracantha contracta*, the tubules are six in number and originate at the union of the mid-gut and hind-gut, being equally spaced about the gut. From this region of origin, they then course throughout the body cavity in general, winding about the viscera and finally becoming attached to the wall of the hind-gut at the point where the colon commences.

The method of attachment to the colon is very peculiar and worthy of especial notice. The six tubules come together and are much flattened and closely joined together by connective tissue, (Fig. 19) for a distance of about three millimeters before they branch out to course down the sides of the hind-gut. They do not coalesce into a common duct however, as each tubule can be separated out from the band. There is a sharp angulation in the direction the tubules take before they branch out from the band. The whole arrangement is certainly very specialized, and would appear to allow of the ready movements of the colon without bringing undue strain upon the tubules. There is a possibility that it is an adaptation to a special method of defecation However this point needs further study.

From the points of attachment to the external wall of the colon, each tubule courses in a zig-zag manner down the wall between two bands of longitudinal muscles, (Fig 20). They are in close contact with the wall of the intestine, being held fast by a thick sheath of connective tissue. As they continue down the colon, they become more compressed in nature and finally terminate blindly just before the beginning of the rectum. (Fig. 21).

The brownish color that is observed in various parts of the tubules is evidently due to the concretions previously mentioned. Near the point of origin they are nearly circular but become more and more flattened as they approach the point of attachment at the colon.

Histologically, it is observed, that they consist mainly of a thick epithelium, with an outer layer of connective tissue. The nuclei are very large, prominent, and filled with coarse granular chromatin. (Figs. 17-18).

Near their origin they contain a prominent lumen and the epithelial cells are densely packed with urinary concretions. Near their blind endings (Fig. 21) however, they become very bead-like in appearance, due to the large turgid epithelial cells, and greatly compressed, the lumen in many instances being barely discernible.

CONCLUSION.

In conclusion, it is to be noted that in this study of *Meracantha contracta*, there is much more to be accomplished before a complete understanding of the alimentary canal can be secured. More species of the Tenebrionidæ should be studied and comparisons drawn as to the adaptations in the canal, for the particular types of food eaten. There is no question that the type studied is very highly specialized. The degree of this specialization should be determined if possible. Also, the specimens studied show a high degree of parasitic infestation in the epithelial tissue of the mid-gut. This parasite is evidently intracellular in nature. In addition, there are present in the fecal material of the hind-gut, many single -celled organisms, obviously of a plant-like nature, possibly yeasts. These occur in great numbers, in strings and singly, in the posterior region of the gut, but are found only sparsely in the anterior region. These should be identified and their effect upon the alimentary canal investigated. In addition the relation of the nature of the bark eaten and the morphological adaptations should be compared. The physiology of the digestive system should be worked out with fresh material in order to understand the anatomical relationships.

In brief, it can readily be seen, therefore, that only a start has been made in this study, and that the pursuit of one problem has opened the need for investigation of many more.

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EXPLANATION OF PLATES.

PLATE I.

FIG. 1. Dorsal view of the abdominal viscera and the portion of the alimentary canal visible.

FIG. 2. Ventral view of the abdominal viscera and the portion of the alimentary canal visible.

FIG. 3. Relative position of the alimentary canal including the Malpighian tubules, in the body of the insect. (Complete fore-gut not shown.)

FIG. 4. Longitudinal section through the head and fore-gut. The fore-gut is extremely short and the anterior end is marked by the powerful mandibles and molar crushing surfaces.

FIG. 5. Cross-section through a portion of the fore-gut. The thick layer of circular muscles is most evident in this section.

FIG. 6. Longitudinal section through the oesophageal valve. The spiny character of the fore-gut, the proventriculus, the flaps of the valve, the crossing of the longitudinal muscles from the fore-gut to the mid-gut and the circular muscle bands causing the ringed appearance of the mid-gut, are structures emphasized in this figure.

FIG. 7. Diagrammatic sketch showing the flaps or folds of the oesophageal valve.

FIG. 8. Diagrammatic sketch showing the relation of circular and longitudinal muscles at the anterior end of the mid-gut.

PLATE II.

FIG. 9. Diagrammatic sketch showing ramifications of the tracheoles throughout the muscles in the walls of the mid-gut.

FIG. 10. Cross-section through a portion of the wall of the mid-gut. The nuclei fade out near the distal ends of the digestive cells, which are ruptured, allowing their secretions to be poured out into the lumen of the mid-gut. A heavy infestation of parasites occurs in the epithelium.

FIG. 11. Longitudinal-section through the pyloric valve, showing the nature of the valve and the abrupt transition from the mid-gut to the hind-gut. A Malpighian tubule is seen entering the lumen of the alimentary canal just anterior to the commencement of the chitinous intima of the hind-gut.

FIG. 12. Cross-section through the hind-gut in the region of the colon. The six strong bands of longitudinal muscles are illustrated, with the Malpighian tubules between them. The flattened character of the epithelium is noticeable.

FIG. 13. Longitudinal-section through the union of the hind-gut and the rectum. This sketch shows the thick layer of circular muscles in the anterior end of the rectum and the abrupt transition between the two regions.

FIG. 14. Cross-section through the rectum illustrating the rectal pads.

FIG. 15. Cross-section through a rectal pad. The surface of the pad is very convoluted and powerful circular muscles underly the epithelium.

FIG. 16. Longitudinal-section of a Malpighian tubule showing the large nucleus and concretions of waste products.

FIG. 17. Cross-section through a Malpighian tubule near its union with the alimentary canal at the pyloric valve.

FIG. 18. Cross-section through a Malpighian tubule near its attachment to the hind-gut.

FIG. 19. A diagrammatic sketch of the peculiar band-like arrangement of the Malpighian tubules at the point of attachment to the walls of the hind-gut.

FIG. 20. Diagrammatic sketch illustrating the arrangement of the longitudinal muscle bands and the Malpighian tubules on the wall of the colon.

FIG. 21. Diagrammatic sketch showing the blind ending of a Malpighian tubule near the rectum.

ABBREVIATIONS USED IN THE FIGURES.

AB	Abdomen.
BC	Buccal cavity.
BM	Basement membrane.
BR	Brain
C	Colon.
CM	Circular muscles
CMB	Circular muscle bundles.
CNS	Concretions
CT	Connective tissue.
E	Epithelium.
FG	Fore-gut
HD	Head
HG	Hind-gut.
HP	Hypopharynx.
IL	Ileum.
INT	Intima.
LBI	Labium.
LBR	Labrum
LM	Longitudinal muscles.
LN	Lumen.
MD	Mandible.
MG	Mid-gut
MS	Molar surface.
MT	Malpighian tubule
N	Nucleus.
NID	Nidus.
OE	Oesophagus.
OUF.	Oesophageal valve flaps.
OV	Oesophageal valve.
P	Pharynx.
PAR	Parasite.
P INT	Primary intima.
PM	Peritrophic membrane.
PV	Proventriculus.
R	Rectum.
RO	Reproductive organs.
S INT.	Secondary intima.
SP	Spines.
T	Testes.
TH	Thorax.
TR	Tracheoles.
1, 2, 3, 4, 5	Abdominal segments.

Alimentary Canal of Mericantha
Warren C. Miller

PLATE I.

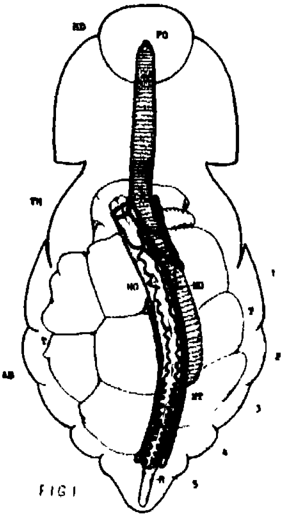


FIG 1

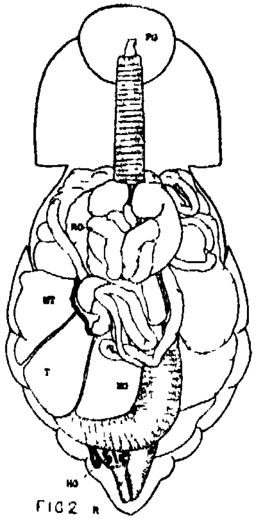
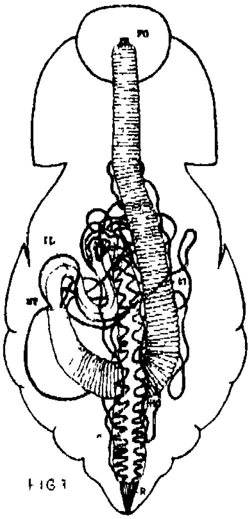


FIG 2



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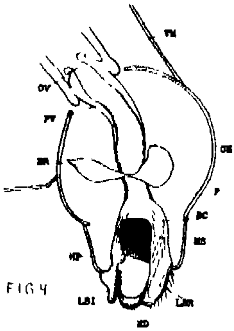

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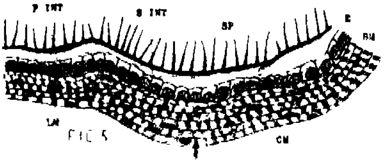

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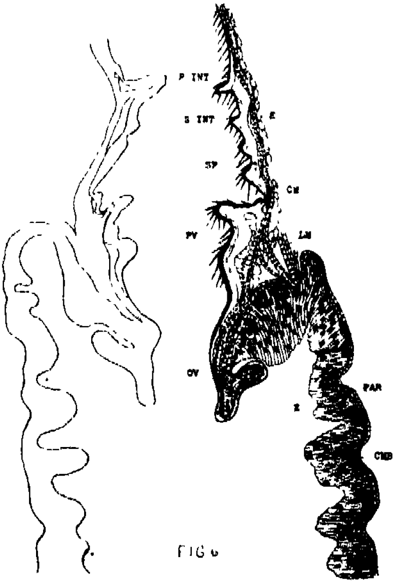

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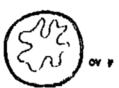

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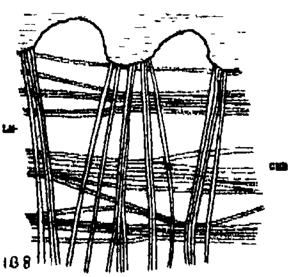

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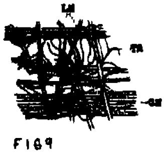

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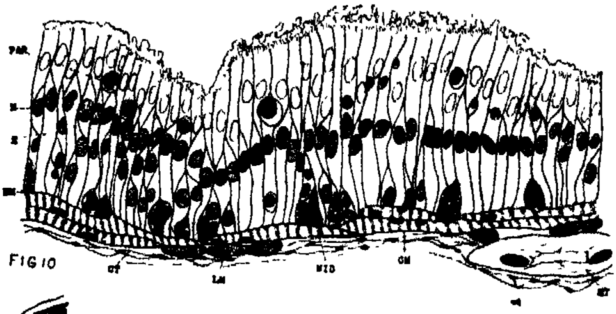

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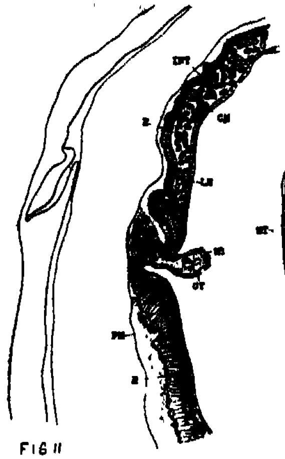
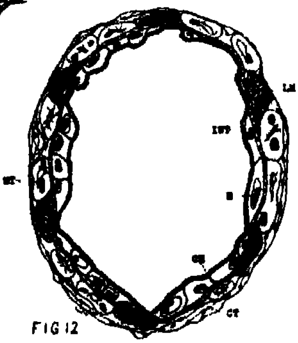


FIG 11



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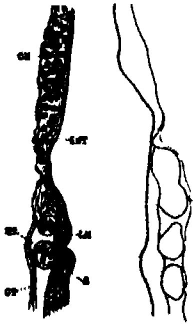

FIG 13

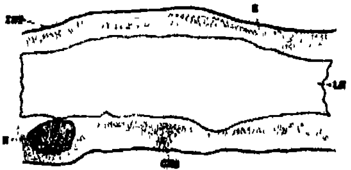

FIG 16

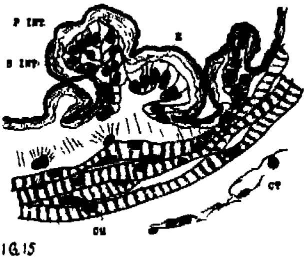

FIG 15

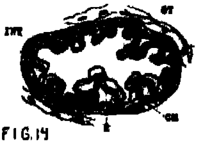

FIG 14

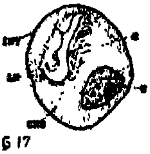

FIG 17

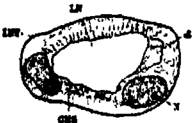

FIG 18

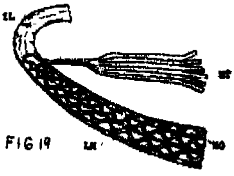

FIG 19

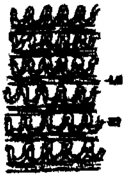

FIG 20

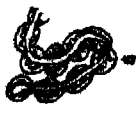

FIG 21

THE GRASS BALDS OF THE GREAT SMOKY MOUNTAINS OF TENNESSEE AND NORTH CAROLINA.*

W. H. CAMP.

Within the relatively small area comprising the Great Smoky Mountains of Tennessee and North Carolina may be found the richest flora, and surely, in its virgin condition, the most luxuriant deciduous forest on the whole North American continent. It is, with the rest of the great Unaka range, the natural dispersion center of the eastern deciduous forest, and contains such a relatively great number of endemic species that it stands unique as a vegetation center.

There are four major reasons for this unusual floristic development.

First.—The region is about four hundred miles north of the Gulf of Mexico and three hundred miles east of the Valley of the Mississippi, being thus assured of a fairly constant supply of moisture-laden winds.

Second.—The peaks are relatively high. There are seven in the eighteen miles between Clingmans Dome and Mt. Guyot that stand over 6,000 feet and in the whole Unaka range there are over forty of this type, with a considerable number of peaks having an altitude of more than 6,500 feet, many of them rising over a mile from their immediate bases. These altitudes are sufficient to keep the upper slopes almost constantly bathed in fog, a feature responsible for the name given these mountains. This type of relief has also given rise to deep, well protected valleys or "coves" with an abundant supply of moisture at the lower as well as the higher levels. The height to which the major peaks rise also brings about a constant floristic succession due to altitudinal effects.

Third.—The region was but little affected by the Pleistocene glaciation. The nearest continental ice was over two hundred miles away, with the Cumberland range a probable barrier to the incidental winds blowing from off the polar cap. In addition, the deep coves of the lower altitudes afforded ample protection during the occasional periods of lowered temperature.

Fourth.—The Appalachians, an almost unbroken chain, stretched for nearly a thousand miles in a north-easterly direction, tapping the reservoir of post-Cretaceous, circumpolar plant migrants.

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*Paper from the Department of Botany, the Ohio State University, No. 273.

THE BALDS.

There are two types of "balds" which occur in the Great Smoky Mountains, the "heath bald" and the "grassy bald." Both types are essentially treeless, the heath bald being dominated by woody ericaceous species, while the grassy balds appear to be consistently herbaceous.

Cain ('30), who made a statistical analysis of the heath balds of the Mt. LeConte area, concluded that they were post-climax, developing on the windward side of the upper slopes and peaks above 4,000 feet after the disturbance of the original forest. He recognized several types, depending upon the altitude at which they develop and the contiguous forest associations from which they were derived, being best developed as sub-alpine types above 5,000 feet in the spruce-fir zone.

The grassy balds, in the area under consideration, develop on the rounded tops and slopes mainly between 4,500 and 5,700 feet, and are surrounded by a deciduous forest. It is to be noted that the heath bald typically develops in the northeastern part of the area mainly within the limits of the spruce-fir zone, while the grassy bald is best developed in the southwestern part where the spruce and fir are absent.

THE GRASSY BALDS.

It has long been the belief of those who have speculated on the origin of the grassy balds, that the early settlers of nearly a hundred years ago cleared or burned off the tops of these ridges in order to produce a grazing place for their stock. It is not the purpose of the present writer to cast any aspersions on the actions or purposes of the pioneers who settled in the broad fertile valleys such as Cade Cove, but it does not seem reasonable that those sturdy peoples, frugal as they were, would have taken the trouble to make such an extended system of pastures as has existed for at least a century.

The pastures would have been over 3,500 feet above their home sites and five or ten, or more, miles distant, necessitating either the removal of responsible members of the family from the fields below, or the hiring of special herders for the stock, the general plan at the present time. Roads had to be built* and the water supply, at best not overly abundant on the balds, had to be watched. It seems to the writer, rather, that if these early settlers went to the trouble to burn and clear these distant mountain tops, they did it merely to *enlarge grassland areas already present* and not to create new ones.

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*Making a new road to the "top" was a community event and was a matter of deep concern. Early in the last century a road was to be built from Cade Cove to the top in the general direction of Thunder Head. The argument waxed hot

It is true that grazing and fire have been the important factors in the changing physiognomy of the balds, but with this in mind, an examination of the region over a period of three years and at various seasons from the Little Tennessee River (1,500 ft.) to Parson Bald (4,700 ft.), and from Cade Cove (1,800 ft.) to Gregory Bald (4,957 ft.), and along the state line ridge to Little Bald (4,700 ft.), gave no hint that these factors have been the ones which gave rise to the typical grassy bald.†

FACTORS IN THE DEVELOPMENT OF THE GRASSY BALD.

In the northeastern portion of the Great Smoky Mountains abundant stands of spruce and fir occur at the higher altitudes. In ascending a typical mountain in this portion of the area, such as LeConte (6,593 ft.), one may observe that the rich lowland mixed forest (1,500 ft.) soon gives way to a dryer forest containing a greater percentage of oak and chestnut and finally pine. Within a few hundred feet the situation is reversed; the pines give way to the oak-chestnut type. At still higher elevations the maple, and beech moves out of the coves and onto the slopes. Above 4,500 feet the beech appears on the ridges where it mingles with the birch and finally above 5,000 feet with the spruce and fir, often occurring in pure stands, but dwarfed by the moist cool climate of the higher altitude. The spruce and fir occur on the higher slopes and peaks, in the region of almost perpetual fog.

There is no doubt about the constant water supply of the spruce-fir forest, for when the writer visited the area in September following the most unusually dry summer of 1930 there seemed to be no great dearth of soil moisture at the higher elevations in spite of almost complete lack of rain since June.

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as to which of two ascending spurs should be chosen. A vote was then taken and it was a tie. One of the settlers who had not yet voted, a native of northern Europe, said: "I bote vor dis vun." In the "Cove" they still speak of "Bote Ridge" and "Defeat Ridge."

†The writer has not made a study of the most easterly balds, as Silers Bald; consequently any statements do not include that area.

During the summer season there is an almost continual patter on the forest floor made by condensed moisture dripping from the trees. In addition to the "drip rain" of the spruce-fir forest, these mountain tops usually have an annual precipitation perhaps in excess of 60 and sometimes estimated at over 80 inches.*

It is thus evident that there is a reversal in the forest types as one ascends in the northeastern part of the area, the lowland forests being mainly moist and warm, the middle forests dry and the upper again moist but cool.

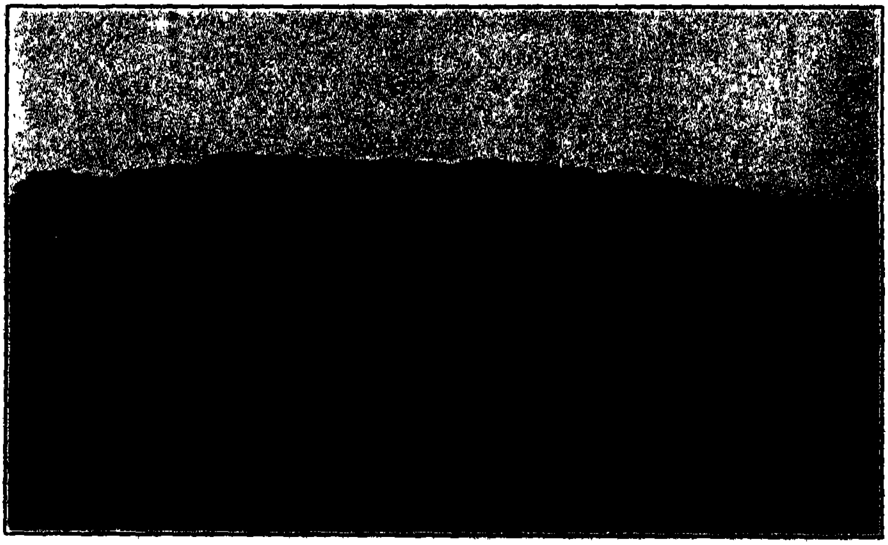

FIGURE 1. GREGORY BALD.
The general aspect of the eastern margin of the bald. The grass in the foreground is mainly *Danthonia compressa.*

The ascent of a mountain in the southwestern portion of the area typically gives the following gross succession. This particular one is taken on the main northeast facing ridge rising from Cade Cove to Gregory Bald.

The valley of Forge Creek (2,000 ft.) contains the usual rich, mixed deciduous forest with hemlock, white pine and rhododendron. Above this, the exposed slopes (somewhat modified by excessive cutting and fire) soon change to an oak-pine complex. At 3,000 feet the pines are very abundant, giving way to the chestnut-chestnut oak type at 3,500 feet. Above 3,500 feet the chestnut oak is slowly replaced by red oak.

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*No data is available for the peaks of the Great Smoky Mountains, but comparable altitudes in the Blue Ridge have an annual precipitation of nearly 100 inches.

Above 4,000 feet an occasional beech is seen, the dominant forest being red oak-chestnut-red maple-chestnut oak with an occasional magnolia (*M. fraseri*). At 4,500 feet the red oak-chestnut-red maple type is still dominant, but in the sag (about 4,750 ft.) just below the bald, beech is much more common, with a scattering of birch and buckeye. Within the next 50 feet the mesophytic species disappear leaving a practically pure stand of chestnut-red oak. As one ascends, this chestnut-red oak forest becomes more and more stunted until it is less than twenty feet high, suddenly giving way to a low, dome-shaped treeless area—Gregory Bald—at an elevation of 4,957 feet. (Fig. 1).

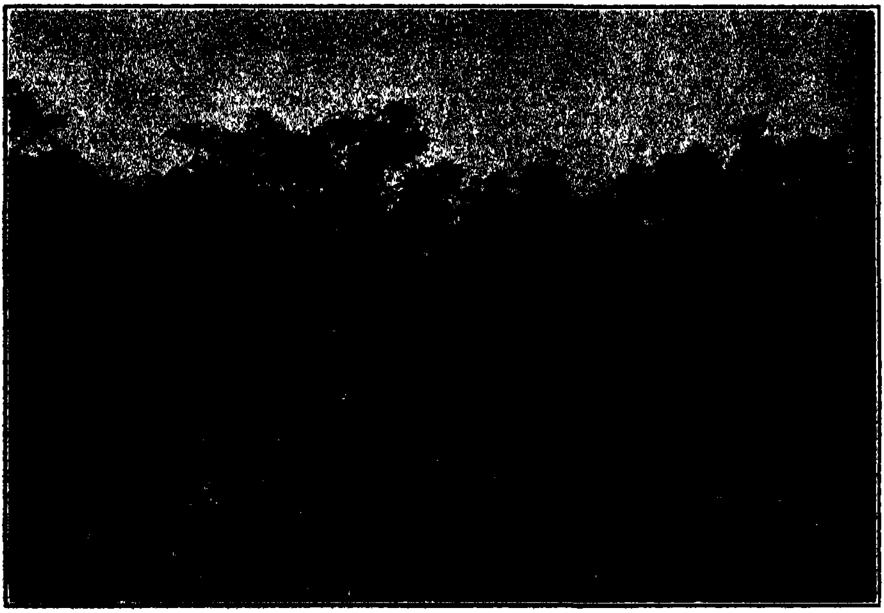

FIGURE 2. GREGORY BALD.
Detail of the southern margin of the bald. The trees (red oak and chestnut) are 6–10 feet tall. The browsed shrubs are mainly Vaccinium and Salix. Figures 1 and 2 were taken in a driving fog.

At first glance the bald seems to be an open grassland completely devoid of woody species, the low meadow vegetation stopping abruptly at the edge of the dwarf forest. A closer examination reveals that in a few places shrubs six to eight feet high occur between the open grassy area and the forest. A still closer examination shows that the meadow is by no means a pure herbaceous association, but has a zone around the edge sometimes over fifty yards wide, which contains a high percentage of woody species so closely browsed that whole areas may stand less than six inches high. (Fig. 2.) These areas of browsed shrubs are by no means confined to the margin of the bald, but occur in scattered patches over the lower slopes, thinning out toward the top.

The determination of the species making up the woody flora of the bald has been exceedingly difficult owing to the closely browsed condition of the plants. Consequently the writer does not feel justified in presenting a floral list and in those plants noted freely admits the possibility of error.

In September, 1930, the larger shrubs of the bald were Crataegus (*C. macrosperma* and possibly *C. roanensis*) and Azalea (*A. lutea*). The smaller shrubs were represented by Vaccinium spp., (one type somewhat resembling *V. corymbosum*), Salix spp., (*S. tristis* often formed dense mats, while another form with sprouts about one foot high greatly resembled *S. discolor*. *S. humilis* may also have been present) and in addition, numerous clumps and individuals of *Xolisma ligustrina*. *Epigaea repens* also was fairly common.

The more open grassy areas contained an abundance of *Danthonia compressa* and *Juncus tenuis* with additional grasses, sedges, etc., and other herbaceous types, such as the pin-weed, *Lechea* (*L. racemulosa* or *L. leggettii*) and *Viola pedata*, including a goodly number of obviously adventive "weeds" of the lower pastures.

Because of the scantness of remains of the original covering and the evident disturbance of occasional fires and decided over-grazing, it is very difficult to reconstruct the original vegetation type of Gregory Bald as it was before the advent of the white man. In his general statement concerning the grassy balds, Cain ('31) concluded that they are natural phenomena for the "soil profiles show from a few inches to a foot or more of homogenous black soil of grassland type, which is too deep and mature to have developed since the advent of the white man, with the possibility of his having cleared off the trees."

While in general this statement is correct, the writer encountered a certain unevenness or "spotty" nature in the distribution of the black soil. In certain restricted areas this could be traced to excessive erosion initiated by the pawing of animals, particularly sheep. However, taken as a whole, this is not true for the bald and it is the opinion of the writer that the area was not originally a pure grassy meadow, but one with numerous "shrub islands" of various types. This view was substantiated by Mrs. John Oliver, long a resident of Cade Cove, who said that she "had it from the older folks long dead" that Gregory Bald was "originally a blueberry meadow" and had "always been a bald."

The present high percentage of willow in the shrub population is no doubt due to the ease with which willow regenerates in heavily grazed areas by vegetative means. It is also true that grazing, particularly by sheep, is decidedly injurious to certain Ericaceous species. With this in mind, it seems probable that Gregory Bald was once dominantly a heath bald, containing open spaces with a heavy covering of grasses, sedges and other herbaceous species. This type of bald is distinctly a dry one, having little in common with the heath bald developed at the higher altitudes in the moist spruce-fir zone, and is easily the dryest bald type of the whole Great Smoky Mountain range.

In considering the factors underlying the production of the "grassy bald," the writer has already mentioned the fact that in the area where the grass balds develop there is a sudden appearance of a scrub forest near the top of the ridge, the last forest sometimes being a stunted chestnut-red oak type. The altitude and steepness of slope are not the determining factors, for comparable altitudes and steeper slopes some miles to the northeast support a thick stand of beech, birch, spruce and fir. The writer can give no plausable causative factor other than the following. These balds occur in the southwestern portion of the range and are more exposed to the dry and sometimes hot southwesterly winds that occasionally sweep in across the valley of the Little Tennessee River in mid-summer. The effect of these desiccating winds is easily noted by climbing from the river to Parson Bald or Gregory Bald, for as one ascends, the forest becomes more open and park-like with numerous small grassy areas often containing a considerable dry heath population. It is not meant to convey the impression that all the southwesterly winds are dry and hot, for the grassy balds are often bathed in fog, but in mid-summer there are occasional periods of excessive drought, and it is this extreme that limits the character of the bald rather than the general climatic mean.

SUMMARY.

There are two major types of treeless areas or "balds" which occur in the Great Smoky Mountains of Tennessee and North Carolina, the "heath bald" and the "grassy bald."

The heath bald typically develops on the upper slopes and peaks, being best developed above 5,000 feet in the northeastern part of the range mainly within the area of the spruce-fir forest.

The grassy bald develops on the rounded tops and slopes between 4,500 and 5,700 feet in the southwestern part of the range and is surrounded by a deciduous forest.

A study of the area surrounding Gregory Bald led to the following conclusions:

1. The grassy balds were originally meadows containing numerous clumps of low shrubs, dominantly Ericaceous, with higher shrubs at the margin.
2. The balds were already present at the advent of the white man.
3. Any clearing that the early settlers did was not to produce grassland areas, but merely to enlarge those already present.
4. The grassy balds of the *southwestern portion* of this range are a natural phenomenon probably produced by occasional desiccating southwesterly winds, their grassland character being intensified during the last century by fires and decided over-grazing.

The writer wishes to acknowledge the assistance of Prof. J. H. Schaffner, of the Ohio State University, in the identification of certain plants, and the suggestions given by E. F. McCarthy, Director of the Central States Forest Experiment Station, who spent a number of years in this general region.

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A PRELIMINARY POLLEN ANALYSIS OF THE EAST McCULLOCH PEAT BED.*

GEORGE H. LANE.

This paper reports the results of a preliminary study of a column of peat taken from the East McCulloch peat bed in northern Iowa. The object of the completed study will be to reconstruct the course of post-glacial climate in that region. The present report must of course be regarded as subject to future modification and correlation.

The percentages of pollen found preserved at successive depths of the peat bed have been taken to indicate the composition of the vegetation about the bog when successive strata of peat were formed. Changing percentages of pollen are construed as suggesting a changing vegetation and a corresponding change in climate.

THE PEAT BED.

The East McCulloch peat bed lies in Section 32, Twin Lake Twp. (Twp. 94 N, R 24 W) Hancock county, in north central Iowa. It covers an area of perhaps eighty acres. The bog was drained in 1920.

Hancock county lies near the eastern edge of the area once covered by the Wisconsin glacier. The soil survey of Wright county (1) (just south of Hancock county) describes the topography of that county as follows: "The country has two general types of topography, a relatively smooth till plain and a morainic hilly region. A line drawn from the center of the northern boundary of the county to a point on the southern boundary about five miles west of the southeast corner will roughly divide the till plain on the west from the morainic hills on the east." The soil survey of Hancock county is not yet available but the range of morainic hills mentioned extends on northward into this county. The East McCulloch peat bed lies about a mile within these hills.

Presumably, these hills mark a period of slow recession with numerous readvances of the glacial ice while the comparative smoothness of the till plain would suggest rapid melting. Since the East McCulloch peat bed lies just within these morainic hills, its pollen record may be expected to include most of the period following the beginning of the rapid retreat of the ice.

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*Contribution from the Botanical Laboratory of the University of Oklahoma, N. S. No. 10.

MATERIALS AND METHODS.

Samples were taken during the summer of 1929 with a Davis peat sampler at six inch intervals through the depth of the peat bed. These were temporarily wrapped in newspaper and later transferred to one half pint tin paint cans and treated in a pressure cooker to prevent bacterial action. When opened in the laboratory the samples were in perfect condition.

TABLE I.

FOSSIL POLLEN BY PERCENTS FOR EACH FOOT OF DEPTH IN McCULLOCH BOG.

	Top	1′	2′	3′	4′	5′	6′	7′	8′	9′	10′	11′	12′	13′	14′	15′
Abies	1			3	2	1			.	1	5	16		24		11
Acer		.			1					.	1					
Amaranthaceæ and Chenopodiaceæ	6		8	32	22	37	5	11	21	17	6					
Betulaceæ			1	1					1	1	11	28		16		1
Carya				1	3		4	2	5	5	5	..	.	1		.
Compositæ	1	4	7	1	3		3	1	4	7	3	1	.	3		2
Cyperaceæ	21	4		7	14	7	7	10	8	7	6	3		1		
Fagus											1	1				
Gramineæ	39	74	70	33	24	25	69	60	23	17	13	14	..	5		3
Juglans..										. .	1	....	.	1		
Picea	1		2	1	1			1	1	1	1	8		20		69
Pinus ..	1	4	1	1	2	3	1	1	4	5	4	1	.	6	.	11
Potamogeton	1			1	1	1					1	.	...	.		
Quercus	3	5	4	2	6	4	3	4	20	27	23	14	.. .	11		3
Salix	1		3	1	2			2	2	1	... .	. .	....	7	.	.
Sparganium	5	1		1	1	10	...	1	2		8	4				.
Tilia		.		. .	1	.	..	. ..	1		1	.				..
Typha	..	.	1		1	1				1	1	..	....	1	..	..
Ulmus				.				.	..	.	1	1	..	1		.
Unknown	20	8	9	16	7	2	8	8	9	11	9	9		4		1

Separation of the pollen from the peat was accomplished in the usual way (3). All reagents used were filtered.

The determinations of the pollen were made with the aid of the key and drawings of Sears (2). Dr. Sears' personal collection of fresh pollen slides was also very helpful in many cases. In a great many instances the oil immersion lens was resorted to for identification of the pollen. For such forms as

Quercus, *Salix*, *Acer*, and in many cases the Gramineæ, the oil offered means of certain identification when the 4 mm. lens left some doubt.

RESULTS AND DISCUSSION.

Table I is a complete list of all pollen counted from the peat core. Each six-inch level was studied separately and the resulting numbers were totaled for each foot of depth. At least one hundred pollen grains were counted from each six-inch level. The presence of spores of Fungi, Bryophytes, and Pteridophytes was noted but they were not included in the total on which the percentages were based

The groups which appear in greatest numbers at each level are indicated by bold faced type in each depth column.

Figure 1 is a diagram showing relative abundance of pollen of different taxonomic groups at each depth.

At fifteen feet spruce pollen is most abundant with other conifers making up most of the rest of the pollen found. Spruce diminshes greatly at thirteen feet but maintains parity there with fir and birch which have increased greatly. Birch forges to the front in quantity of pollen at eleven feet while fir is disappearing and oak and grasses appear in moderate quantities. At the ten and nine foot levels birch, spruce, and fir are markedly on the wane while oak appears in increasing quantities. In the nine foot level amaranthaceous pollen makes its first considerable appearance. Amaranth reaches major proportions in the eight foot level while oak is diminishing and grass remains practically constant. At the seven and six foot levels grass pollen becomes the major constituent and amaranth pollen is considerably less abundant. All tree pollen is comparatively rare in the seven foot and succeeding levels. At five, four, and three feet amaranth pollen again becomes a major part of the pollen found but it again disappears in the three upper levels as grass pollen again increases.

Assuming these pollen percentages to represent the composition of the vegetation the changes shown in this peat bed are—(1) spruce forest, (2) mixed fir, birch, and spruce, (3) birch with fir and oak, (4) oak with birch and grasses, and (5) grassland vegetation from here up with a strong semi-arid element at the nine to eight foot levels and again at the five to three foot levels.

Again assuming that these vegetation units have been dependent in the past on the same climates that control them

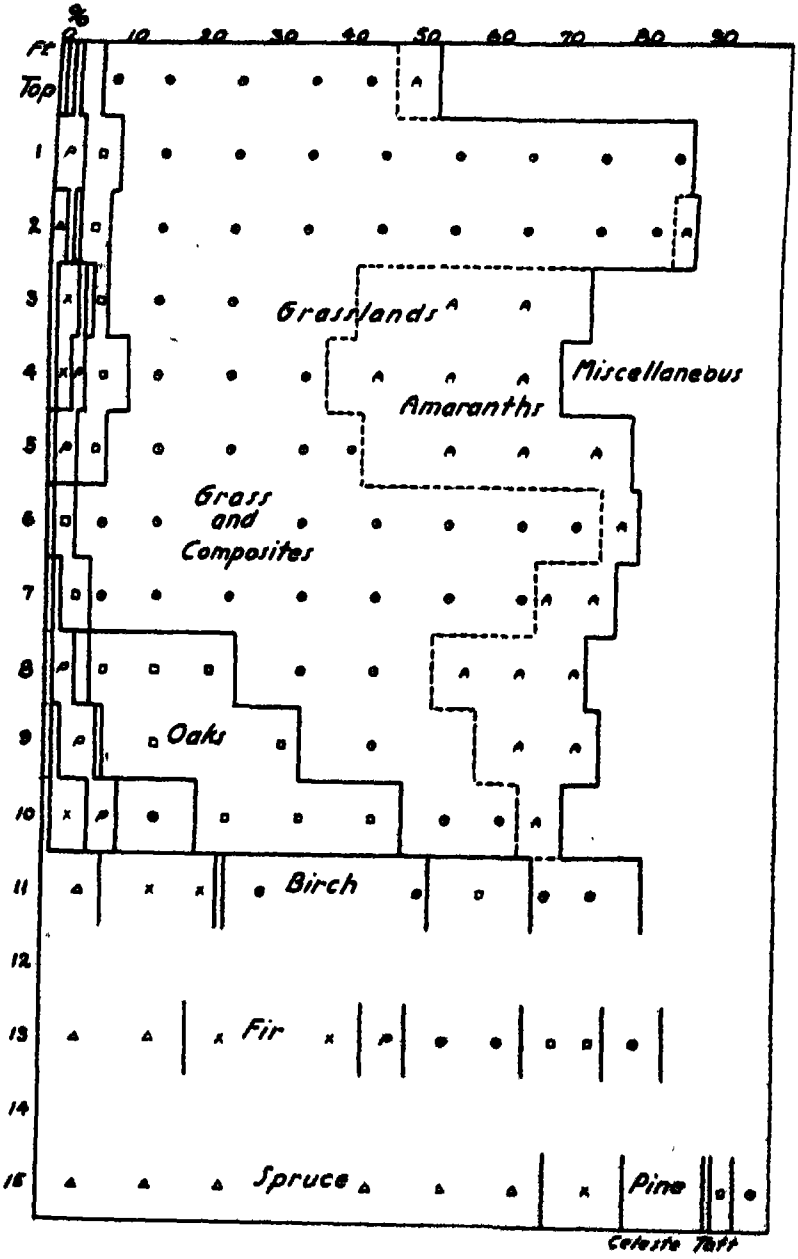

FIGURE 1.
Porportions of different fossil pollen at successive depths.

today we may draw three climatic inferences from this succession of vegetation, (1) warming influences which accompanied the change from coniferous to deciduous forms through the lower quarter of the peat bed; (2) gradual dessication of the climate through the lower half of the peat bed culminating at eight feet; and (3) continuous grassland climate from this point onward with a second period of dessication which reaches a maximum about the four foot level.

In figure 2 the pollen of each genus or family is graphed in columns representing their probable climatic preference.

The following table presents this grouping:

TABLE II.

ASSUMED CLIMATIC SIGNIFICANCE OF FOSSIL POLLEN.

UNKNOWN	LAKE MARGIN PLANTS	CONIFEROUS FOREST CLIMATE			DECIDUOUS FOREST CLIMATE			GRASSLANDS CLIMATE	
		Moist	?	Dry	Moist	?	Dry	?	Dry
	Cyperaceæ Potamogeton Salix Sparganium Typha	Abies	Picea	Pinus	Acer Fagus Juglans Tilia Ulmus	*Betulaceæ Quercus	Carya	Gramineæ Compositæ	Amaranthaceæ

The climatic shift suggested above is borne out in the chart, Fig. 2. Coniferous pollen is of little importance above eleven feet. Herbaceous pollen is most abundant above nine feet. Deciduous tree forms are important only in the eleven to nine foot levels. Correlated with sharp increases in the "Grassland-Dry" column are sharp increases in the column "Lake Margin Plants." It would be expected that climatic dessication would result in lowering lake levels and an increase in these plants. Increase in the latter in the "Top" level where there is no corresponding increase in the "Grassland-Dry" column is largely Cyperaceæ pollen and is probably a result of draining the bog.

That the phenomena indicated above the thirteen foot level are to be correlated with the two dry post glacial periods postulated by Auer (5) and Sears (4) appears likely from the fact that this column runs well back into the post glacial coniferous forest period.

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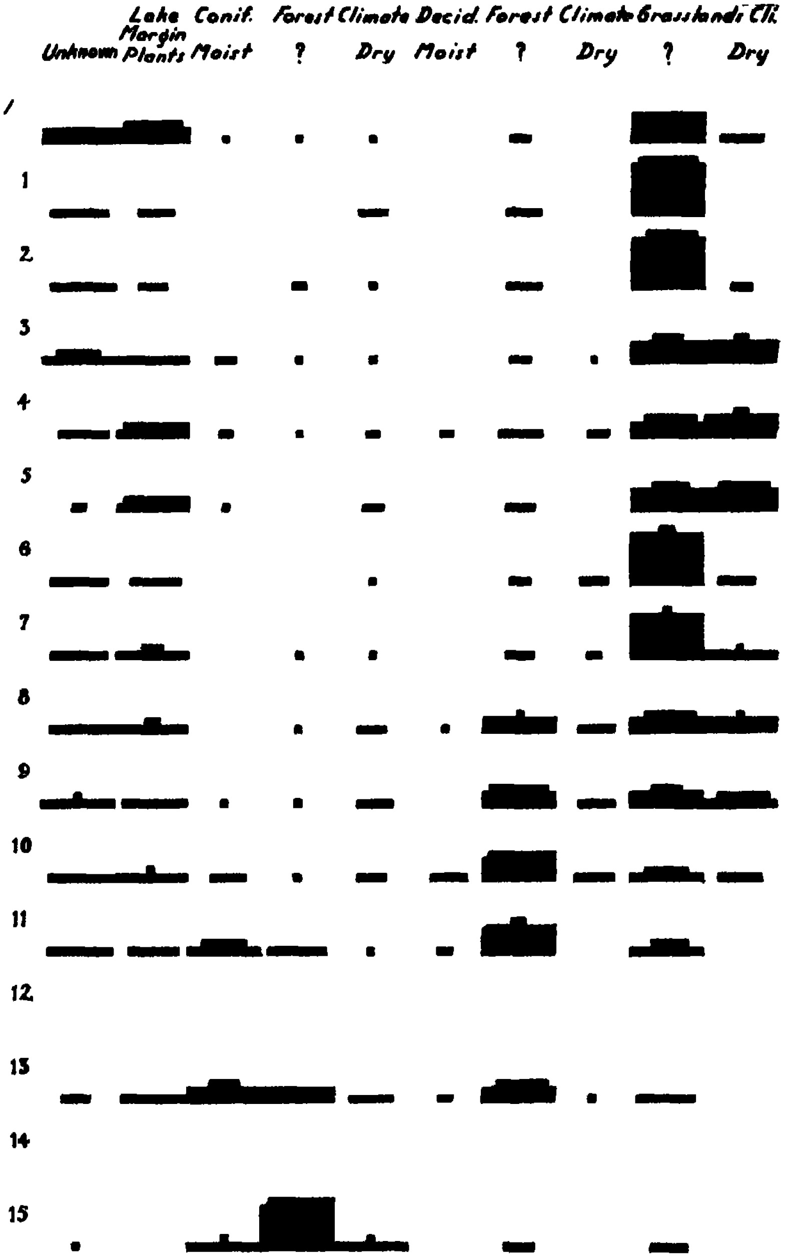
*The Betulaceae may with some reason be regarded as indicators of a cool dry phase of the deciduous forest climate. This is consistent with their position in the accompanying charts and agrees with results obtained in Indiana, shortly to be published.—P. B. S.



Celeste Taft

Fig. 2. Proportions of different fossil pollen at successive depths, grouped by probable climate significance.

Above eight feet but little tree pollen is to be found though there is some in each level. Each genus varies from level to level but these variations are of too low an order to be regarded as significant. There is no indication from this study that the forest is replacing grassland in Iowa. It would seem, on the other hand, that the status of the Iowa Prairie as a climax formation would be strengthened since it appears to have developed in the place of a former forest as a response to present climatic conditions.

SUMMARY.

1. Pollen analysis has been applied to the study of peat from the East McCulloch peat bed in south central Hancock county, northern Iowa.

2. Fossil pollen found suggests the following succession of vegetation: (a) Spruce at 15 ft., (b) fir with spruce and birch at 13 ft., (c) birch with fir and oak at 11 ft., (d) oak at 10 and 9 ft. with entrance of herbaceous forms at 9 ft., (e) grasslands from 8 ft. upward with considerable amaranthaceous flora at the 8 ft. and at the 5, 4, and 3 ft. levels.

3. Climatic changes inferred from changes in the vegetation are, (a) warming from 15 ft. to 10 ft., (b) gradual drying from 15 ft. to 8 ft., and (c) grassland climate above 8 ft.—of distinctly arid type at the 8 ft. and at the 5, 4, and 3 ft. levels.

4. No indication was found of recent increase of forest although recent conditions appear to be more humid than those of the 3 ft. level.

The author desires to acknowledge his indebtedness to Mr. W. H. McCulloch for the freedom of his farm and for assistance in collecting samples and particularly to Doctor Paul B. Sears, who suggested the problem, for his help and encouragement throughout the course of the investigation.

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"BIRD SANCTUARY" SUGGESTIONS.[1]

S. PRENTISS BALDWIN,
Baldwin Bird Research Laboratory,
Cleveland, Ohio.

"Bird Sanctuary," as intended in the management of Parks, Estates, Cemeteries, or Golf Grounds, really means the conservation of wild life of all kinds, birds, mammals, wild flowers, and all the other interesting things in nature.

This needs to be carefully distinguished from the "shooting grounds," or "pheasant raising" idea of sportsmen whose chief aim is to kill. We believe, then, in the least possible destruction of wild life in a Bird Sanctuary, and that means that coons, possums, and skunks may live there safely and undisturbed. These animals, and especially the skunks, are of great value, where there are lawns, because of their destruction of insects injurious to lawns.

Hawks are mostly useful and valuable, except one or two species, as they are great destroyers of insects and rats and mice. All the wild creatures live and survive and find their place in nature, except as man upsets the balance.

Sanctuary then, to all wild life in order that we may enjoy seeing and knowing them.

Kill? Kill all cats as the worst enemies of all forms of wild life; we must appreciate that, under the protection of civilized life, cats prosper beyond control and become wild and enormously destructive. Do not shoot a cat! It disturbs the neighbors. But cats may be easily trapped. Use traps that do not kill when sprung; this because the traps may catch other forms of life which should be released unharmed.

English Sparrows may be very abundant and consume the grain intended for more desirable native birds. Do not allow English Sparrows to be trapped unless by a person who knows our native sparrows very thoroughly. Our native sparrows closely resemble the English Sparrow, in appearance, but are, in fact, most desirable and attractive birds to cultivate. Consult an expert if you need trap English Sparrows. Red Squirrels do seem destructive to birds and should be trapped and destroyed if they become abundant.

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[1] Contribution No. 20 of the Baldwin Bird Research Laboratory.

Do not destroy any other wild life unless, in special cases, where some serious damage is done.

"Bird Sanctuary"—a popular idea of it is that a limited area be set aside, only a few acres sometimes, and that this be left to the birds, and without habitation of man.

This idea of a bird sanctuary is based upon two mistaken notions:

(1) That the birds will concentrate in such an area for their nesting; this completely ignores the fact that, with the exception of a few colony nesting birds like the martins, or certain sea birds, most of our common birds have a strong claim to territory. A book written about "Territory in Bird Life," by Howard, an Englishman, has made us all realize that each pair takes possession of and holds, during nesting, a feeding territory, and the birds will not concentrate or crowd into a limited area. It is nature's provision to keep them spread out over wide areas for feeding.

(2) That birds thrive better away from human habitation and activities, the fact being that few birds mind in the least the usual activities of human life, about them, and indeed, except for cats, the proximity of human life is a protection to them.

Coming now to more definite suggestions:

(a) A program for a Bird Sanctuary should cost very little in time, labor or money.

(b) The area may be large, full size of park, cemetery, estate, or, indeed, an entire community or village or suburb.

(c) One prime need is some person in charge who is interested and loves the wild life, who can give for an estate or cemetery, two or three half days per week in winter. In selecting the person, find one who will not be tempted to take advantage of the position to trap for pelts.

(d) All year, but especially in spring, operate a few cat traps now and then. *Get rid of cats;* when in trap they may be treated with a spoonful of chloroform, or of carbon disulphide poured in the trap, but be sure the cat is dead, not just asleep before burying, and *Caution*, the gases are poisonous to breathe and very inflammable. Cats may come from a mile or more about, and usually at night, so do not think the wild life is safe just because you do not see cats about in daytime.

(e) During the spring and summer no feeding need be done, but it is very desirable that some nest places be provided; also good cover of living shrubs, and brush and evergreens.

(f) **Nest Places:** Where there are trees in the natural state of some being rotten or broken, and bored by woodpeckers, it is usually not necessary to provide artificial nest boxes. But the modern tree surgery, where thoroughly done, results in closing up or cutting out every possible nest site for the birds nesting in holes or boxes. Nest boxes may then be provided in any of the simple forms, not too many, not more than four to the acre; and all boxes must be so made that the top or side may be opened for cleaning out

(g) Winter Feed Shelters: Suitable to attract and protect quail and all the other birds.

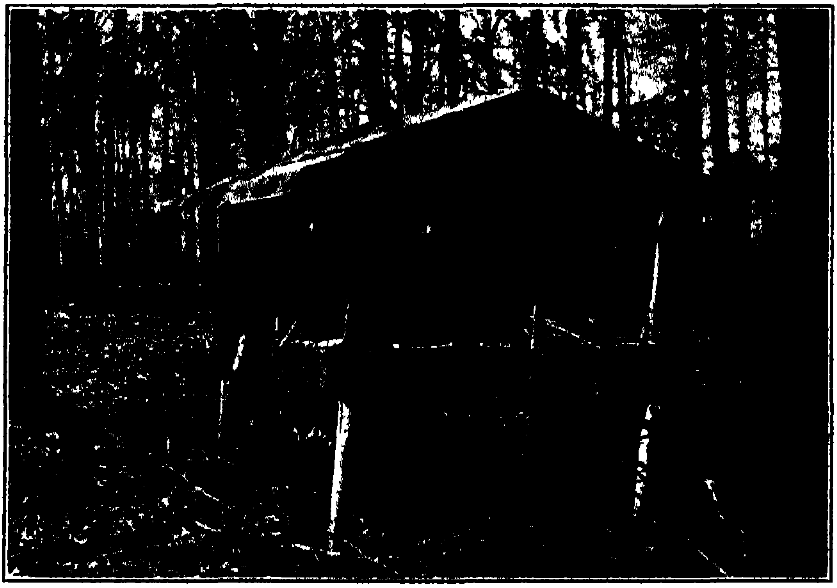

FIG. I. An Effective Form of Food Shelter.

Square simple wood frames, four corner posts, and waterproof roof; rough sides, especially on north and west, one side on the east or south entirely open, but, on at least two sides, boards must be off at the base so birds may escape if an enemy suddenly appears at the open side Feed may be thrown on the ground under the shelter; and a second feeding place provided by constructing a floor, or platform, two feet above the ground.

The best protection requires that coarse brush be piled about and in the shelter to prevent the possible sudden rush or attack by enemies, and give the birds a chance to escape, in case of such attack.

Supply here constantly, fine gravel, sunflower, buckwheat, cracked grain, or poultry scratch feed, and some minor portion of finest baby chick food for the smallest birds, suet, fruits, apples, or dried fruits, water if it is very far to water. Not too much grain at a time or it will sour.

(h) Planting to provide shelter and feed: Cover is most important, thickets, shrubs, and wherever possible let the thickets become dense and tangled, and where possible let the weeds grow in wild abandon; the thickets provide shelter from enemies, shelter from sun, and shelter for nests; the weeds provide winter feed that will stand above the snow, however deep. Ravine banks planted to evergreens provide warm shelter for winter.

(i) Water is most important Sometimes, along a brook, walls are built with much care and expense; these walls may completely prevent not only small mammals but even birds from access to water. Allow gaps or breaks every hundred feet to allow access.

PLANTING FOR FOOD SUPPLY:

For summer:

- Mulberry
- Bird Cherry (Prunus)
- Elder
- Thorn
- Bush Honeysuckle
- Shad Bush

For autumn and winter:

- Thorn
- Mountain Ash
- Crab Apples
- Barberry
- Alder
- Viburnums
- Wild Grapes

BOOKS DEVOTED ESPECIALLY TO THIS SUBJECT:

"Bird Friends," by Gilbert H. Trafton, Houghton Mifflin Co., 1916. A very complete handbook on attracting and protecting birds.

"Wild Bird Guests," by Ernest Harold Baynes; E. P. Dutton & Co. Now out of print, but may be picked up from dealers in second-hand books. Several other interesting little books by Baynes. Apply to Audubon Birdhouse Co., Meriden, N. H.

The "Book of Bird Life," by Dr. A. A. Allen, of Cornell; D. Van Nostrand Co., N. Y., 1930.

"Golf Clubs as Bird Sanctuaries," by A. A. Allen. Apply to National Association of Audubon Societies, 1974 Broadway, New York City.

"How to Make a Cat Trap," Leaflet No. 50. For sale by Superintendent of Public Documents, Washington, D. C.; 5 cents.

For traps, write to: A. W. Higgins, Rock, Mass., or Russell S. Davis, Clayton, Ill. (Both will supply bird and cat traps.)

For bird homes, write to: Audubon Birdhouse Company, Meriden, N. H.

For books to identify birds:

- Birds of New York, 106 plates, $1.00 and postage. New York State Museum, Albany, N. Y.
- Birds of New York, two large volumes, same plates, $10.00, New York State Museum, Albany, N. Y.
- Birds of Massachusetts, by Forbush; three volumes finely illustrated; $15.00. Apply to State Ornithologist, State House, Boston, Mass.
- Birds of Pennsylvania, by Sutton; small hand book, $1.25. J. Horace McFarland Co., Harrisburg, Pa.
- Hand Book of Birds of Eastern North America, by Frank H. Chapman. D. Appleton & Co. The standard hand book.

BOOK REVIEW.

HISTORY OF APPLIED ENTOMOLOGY. L. O. HOWARD. Smithsonian Institution, Washington, D. C., 1930.

Entomologists who have been waiting expectantly for Doctor Howard's "History" will be delighted with the appearance of this fine volume filled with anecdotes and reminiscences of the author's fifty years participation in the growth of entomology. The sub-title, "somewhat anectodal," indicates well the nature of the contents, as the work consists very largely of accounts of Doctor Howard's personal associations with entomologists during the past fifty years. For many of the incidents related one would look in vain in any official report or publication. Quite naturally the space devoted to early American entomology deals very largely with the growth of the Federal entomological service, in which Doctor Howard had so prominent a part. His treatment of the growth of entomology in the several states and especially in the Experiment Stations is relatively brief and, as he states, no attempt is made at completeness. A particularly fine feature of the work is the inclusion of some 250 portraits of American and foreign entomologists. The omission of some well known American workers is explained by the statement that portraits were not included for men under fifty-five years of age.

H. O.

MODERN BUILDINGS AND THE TERMITE PROBLEM.

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A recent paper on the subject "Termites Modify Building Codes"* by Dr. T. E. Snyder, has called to our attention the modifications in building codes which have been brought about by the continued and enormous damage of termites in all sections of the United States, but especially the south and southwest. He has stressed three principal points—the insulation of untreated woodwork from the ground by means of proper foundations and proper mortar, metal termite shields to shut off the shelter tubes or tunnels composed of earth, and treatment of interior woodwork and furniture with preservatives. This new building program will undoubtedly bring about decided changes in both the type and permanence of buildings in many parts of the country due to new methods, materials, and new treatments of wood which is used in construction. Such a modification should reduce greatly the more important infestations and losses.

If we confine our attention entirely to the modern building where for the most part the normal precautions for termites have been observed we still find a high percentage of infestation. It is the general opinion even of the average entomologist that the termite should be a factor of minor importance in buildings with modern construction especially in the north, but it is surprising how many buildings are infested and how severe these infestations frequently become. In view of the fact that so many of these have come to the writer's attention during the past few years and many attempts have been made to control them, it might be well to state briefly certain conditions found and problems encountered, all of which are in keeping with the conditions mentioned by Dr. Snyder except that the infestations that are cited here are found in the modern homes in some of the newest and most exclusive subdivisions of Columbus. The building cost of these structures will range from $20,000 to $60,000 at least, and the most modern methods of construction and best materials have apparently been used as far as possible. The proportionate losses are naturally not so great but the termite remains a problem even here and continued losses are suffered.

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*Jour. Econ. Ent., Vol. 20, p. 316. April, 1927.

The subterranean termites have been found to be the type concerned in all infestations observed. These are able to attack wood only by maintaining contact with the earth in order to obtain moisture which is necessary for their survival. If they cross brick or concrete foundations in order to reach wood sills or other timber they construct earthen shelter tubes.

Observations have shown that houses constructed chiefly of brick, stone or concrete, are frequently infested and it is just as easy to find such a modern structure infested as it is to find a modern frame house, with a good brick or concrete foundation, which is infested.

The usual locations of termite infestation, as observations would indicate, in a house constructed chiefly of brick or similar materials, is the hardwood floors. A large number of such infestations have been seen in Columbus where the floor was damaged to the extent that only a very thin shell of wood remained above and eventually some one would walk upon this and it would easily break through. This condition is found especially in corners or other parts of the room where furniture is placed over certain portions of the floor and remains there for some time so that no one walks upon these places for a considerable length of time. It is therefore necessary to replace whole sections of hardwood floors or in many cases boards here and there throughout the room. In either case refinishing of the entire floor is usually necessary. The sub-floor and joist are sources of infestations in many cases. Frequently the whole floor becomes perforated with emergence holes. Other common places of infestation in the modern house are the door sills and door and window frames and casings, large wooden supporting beams, studding and similar structures.

In attempting to trace the source of these infestations it was found that in some cases termites were entering through crevices where the mortar had cracked or crumbled away, or had been removed apparently by these insects forming small passageways between the bricks of the foundation so they could enter here. The termites after entering were working up the brick or concrete wall inside then following a large beam or some wooden structure to the center of the building and working up into the floor and other portions of the building from this point. Attention should probably be called to the conditions which usually favor such a source of infestation. As a rule after excavating for a building and constructing the foundation, a sort of trench remains for some time outside the foundation while the super structure is being constructed. Wooden refuse of all kinds, but composed chiefly of small pieces which have been sawed off and dropped, fall into this trench and are later covered with dirt when the surroundings are graded and landscaped. This forms an ideal condition for termites and is a common source of infestation for the home, as excavations have demonstrated, for they come through the walls frequently below the outside surface or ground line. Antique and other furniture frequently contain termites which destroy the wood and consequently the value of these articles within a short time. In addition, evidence would indicate that this is probably the source of infestation for woodwork and other portions of the household in a few cases where such articles of furniture have been brought into the home.

Probably the most extreme and striking examples of termite infestations are in modern fire-proof buildings. A few such structures are known to be infested in Columbus, although the source of infestation, in many cases, is rather difficult to ascertain. These infestations are found in buildings of brick or concrete construction, finished with metal lath, composition floors and baseboards, metal and glass doors throughout, the only wooden portions being the door casings which are infested and the interior window frames. The losses here of course are comparatively slight as a rule but these are good examples of the extreme conditions under which termites occur in modern buildings.

As a specific example of an infestation of this type and one showing a loss of several thousands of dollars I might cite the recent discovery of termites in large numbers in the basement of the Ohio State University Library. This building was erected in 1913 at a cost of approximately $250,000 (it would cost $400,000 to duplicate it now) and constructed entirely of reinforced concrete, stone and similar materials. No wooden structures of any kind are found in the basement except some tables, chairs and temporary shelves for sets of old periodicals. Upon investigation it was found that when the concrete was poured for the floor of the basement, very minute pores or openings were occasionally left around the wall and supporting pillars where the sand and cement had not entirely filled these openings between the gravel. The termites had come through these openings then had built their mud tunnels up the walls and concrete pillars, worked into the wood shelves then had destroyed many sets of older periodicals which were stored here temporarily. An enormous amount of labor, extra construction, new shelves and replacement of many sets of periodicals have been necessary. This specific example is typical of many similar infestations and losses which could be cited.

If these pests could be easily controlled the problem would not be so serious, but economic control is difficult to accomplish after they are once established and they frequently become established in the modern home as previously indicated. The superheating process in an infested house seems to be the only sure method and this is very hard to accomplish in most buildings because of lack of sufficient heating equipment to raise the temperature to the necessary degree without danger of fire. Fumigation with cyanide and other gases is not successful in many cases since it seems to be impossible to penetrate these inside burrows with gas until after the emergence holes have been made in the wood. Therefore the termite infestation in the house of modern construction still is a problem although the degree of damage has been reduced.

BOOK REVIEW.

THOMAS SAY, EARLY AMERICAN NATURALIST. By HARRY B. WEISS AND GRACE M. ZIEGLER. Published by Chas. C. Thomas, Springfield, Ill., 1931.

We have in this volume a most welcome addition to the literature on early American Entomology as the authors have succeeded in bringing together a very interesting collection of incidents concerning the life of this famous naturalist, much of it hitherto inaccessible or unknown to the entomological fraternity. The book includes a sketch of what could be learned about the Say family, accounts of Say's various travels and explorations and copies of his letters to friends, especially to the Melsheimer's, on entomological matters. There is also a vivid picture of his connection with the community at New Harmony, Indiana, of which he was a part. The illustrations include, beside two portraits of Say, those of Mrs. Say, McClure and LeSeuer, and reproductions of letters, scenes in Philidelphia, New Harmony, etc.

H. O.

HIVE TEMPERATURES FOR EACH HOUR OF A DAY.*

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INTRODUCTION.

Of the climatic factors in the environment of the honey-bee, temperature modifies their reactions more than any other factor. The well known clustering of bees during the winter and the period of normal brooding of honeybees are two distinct physiological conditions within the colony, brought about by the one environmental factor, temperature. The former condition has been the subject of a great deal of experimental work and has been worked out rather thoroughly. On the other hand, investigations on the latter condition have been more or less limited.

This study on the temperatures within the colony was carried on during the summer of 1926.

I wish to express my appreciation to Professor W. M. Barrows for his helpful suggestions and encouragement in many phases of the work; to Dr. E. F. Phillips, Cornell University, for loaning German beekeeping literature pertaining to hive temperatures, and to Mr. Morris Schlosberg, for his help in constructing the compound thermocouple.

REVIEW OF IMPORTANT PAPERS ON HIVE TEMPERATURES DURING SUMMER.

Francis Huber (1791) who was one of the early investigators on bee life, made observations on brooding temperatures. He stated that in hives rearing brood during the month of January he had obtained the temperature of 93 degrees F. He criticized the statement of Dubost, of Bourg-en-Bresse, that larvae could not hatch below 104 degrees F. Huber stated that the ordinary temperature of hives in summer was from 95 degrees to 97 degrees F. One particular observation was made when the outside temperature was 94 degrees F. At the same time in the most populous hive it did not rise above 99 degrees F.

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*Contribution from the Department of Zoology and Entomology, Ohio State University, No. 107.

A. I. Root in 1899 made some observations on the proper temperature for brood rearing. He placed a self-registering thermometer in the center of the brood nest of a medium sized colony and found that the coolest temperature reached during the night period when the external temperature was below freezing was 92 degrees F. In stronger colonies he observed that the temperature registered 95 degrees F. on very cool nights. During a very hot day in August when the external temperature registered from 90 degrees to 95 degrees, he found that in a strong colony the highest point reached was 98 degrees F. In conclusion he stated that the temperatures most conducive for successful brood rearing within the hive were between 92 degrees and 98 degrees F.

Gates in 1914 carried on extensive studies on the temperature within the bee colony during the winter and summer periods. Gates reported some observations which were made in 1908. On March 12th, he opened a hive and found eggs less than 3 days old. At a corresponding time, the course of thermometer c, which was in the region of egg laying, changed; and the inverse relationship which existed during the winter period was no longer apparent. He stated that the trend of the thermometer c was slightly upward during the warmth of the day which corresponded somewhat with the warmth of the outside temperatures. He said that there was a transition from winter to summer (a broodless condition to a condition of normal brood rearing) covering a period of two weeks. In the middle of the brood nest during the summer period, there was no appreciable correlation between the brood temperatures and external temperatures. The hive temperature as a whole was independent of external temperatures, however, a few exceptions to this occurred. The temperature in the brood nest was remarkably constant, ranging from 93.2 degrees to 95 degrees F. The range of the oscillation showed the consistency of the temperature during the height of the season and the greater fluctuations in the spring and fall.

Brunnich in 1919 conducted some research work on colonies rearing brood. All of his observations were taken on weak colonies. Of 27 brood nest readings the temperature was 113.36 degrees F.; 17 were 104 degrees F.; and 7 were 105.4 degrees F. He said that brood did not tend to cool off the hive, but rather was a heat producer which could exist only in an environment of about 98.6 degrees F. He stated that his observations were probably more or less inaccurate.

Armbruster in 1923 published an article on the temperatures within the bee colony. This work summarized the observations carried on by Lammert in 1894 and 1895 and those of Gates in 1914. He referred to Lammert's notes concerning a swarm of bees hived in a burlap sack within which a temperature of 100.4 degrees F. was obtained. After 8 days, the time when a first swarm possesses a good brood nest, normal temperatures of 95 degrees were resumed. Armbruster continued to describe Lammert's work, but in conclusion he stated that this work agreed with Gates' observations in almost every case with the exception that Lammert's temperatures were somewhat higher of the two. Armbruster commented on the few tables presented by Gates and explained that these tables became much more fruitful when arranged in graphic form. In brief, Armbruster believed that the brood nest temperatures never go below 93.2 degrees F. and seldom above 95 degrees F. He said that when the low level of 93.2 degrees F. occurred there was a direct response of the bees to prevent the temperature from becoming any lower; and that when the temperature reached 95 degrees F. there was a direct cooling off response by the bees so that temperatures would not rise above that point.

Hess in 1926 carried on some extensive experiments on the temperature of a colony of bees during winter and summer. He said that inside the brooding sphere 95 degrees to 96.8 degrees F. prevailed whenever extraordinary outside temperatures did not hold sway. He found a variation of only .36 degrees to .76 degrees F. during the course of a day, even though the outside temperature might cover a wide range of variation. He stated that the mechanical regulation of temperatures in bees is as steady as in humans; that is, they have an effective regulation toward low and high external temperatures. On a day in August, when the maximum outdoor temperature was 93.2 degrees F. he placed an electrically heated pad under a colony of bees and obtained a temperature over the honey comb of 104 degrees F., in the broodless region of 100.76 degrees F. and in the sphere of brooding of 96.8 degrees F. Hess thought that only the evaporation of water was effective in lowering the temperature in the brood area.

Milum in 1928 reported some of his observations. He said that apparently 91 degrees to 92 degrees F. were necessary to stimulate the beginning of brood rearing, but that this temperature did not need to be maintained for the continuation of brood rearing. Temperatures as low as 76.3 degrees F. were observed with no apparent ill effects on the brood except that it retarded development. During the spring period, temperatures of 85 degrees F. in the brood nest were not uncommon. When brood rearing had become well established in late spring and summer, the brood area ranged from 90 degrees to 95 degrees F. The highest temperature recorded by Milum was 98.2 degrees F. Temperatures above 95 degrees F. tended to cause the bees to hang outside the hive.

Vansell reported in 1930 a temperature of 108 degrees F. in the brood nest when external temperatures reached 116 degrees F.

CONDITIONS UNDER WHICH THE EXPERIMENT WAS CONDUCTED.

This experiment was performed on the roof of the third floor of the Botany and Zoology Building of Ohio State University, Columbus, Ohio. This place was selected because it was a convenient location, the space was well adapted for an experiment of this nature, and moreover the experiment would be less disturbed here than in any other available place. The colony used in this experiment was of the Italian race of bees.

On June 18th, 1926, the colony in a ten frame standard hive was taken from the college apiary and placed on the roof of the third story near the place where the experiment was to be carried out. On June 30th, two and one-half pounds of young bees were added to the colony so that the total number of bees was 35,000–45,000.

After the colony had become adjusted to this location, it was set back on a platform within the building so it was on the same level as the bottom of a window casing. The lower half of the window was raised and the open space covered with beaver board. The entrance of the colony was extended out of doors by means of a tunnel 14½" x 8" x ⅞". The outdoor entrance to this tunnel measured 4½" x ⅜".

Temperatures within the colony were taken by means of the electrical thermocouple method, but room and outdoor temperatures were taken with mercuric thermometers. The general set up of the compound thermocouple was similar to that outlined by Robinson in the Journal of Economic Entomology, 1927.

Each thermocouple junction was checked for accuracy against a tested mercuric thermometer covering the range of degrees in temperature that might possibly be involved in the experiment. There were eight thermocouple wires running into the hive at various locations, but all were placed at the same depth which was 4½ inches from the top of the hive. The ends of the wire at the thermocouple junction were placed in a thin glass tube, the end of which was closed. To prevent air currents, tape was wound around the open end of the glass tube and also at the place where the glass tubes pass through the inner cover of the hive. The reason for placing the thermocouple junctions in glass tubing was that we desired only representative temperatures of the region in which the thermocouple was located. The glass tubing tended toward avoiding any local influence such as a bee fanning its wings vigorously near the exposed junction, or the placing of propolis on the junction.

HIVE TEMPERATURES FOR THE DAY.

Two days after taking the hourly temperatures of the colony, it was examined and notes were taken on the exact position of the brood, the honey, and the empty comb space. The temperatures occurring within the hive were divided into three distinct classes; those occurring in the central brood area, in the outer brood area, and in the broodless area. Table I gives the temperatures occurring hourly during the experiment. Figure 1 gives a graphic representation of the temperatures prevailing hourly in the different regions within the colony. The two curves designated as room temperature and outdoor temperature represent the external temperature to which the colony was exposed during each hour of the day.

As shown by the curves, the influence of the environmental temperatures has very little, if any, influence on the temperatures of the central brood area. This is shown clearly as the difference between the maximum and minimum temperatures, 94.1 degrees F. and 93 degrees F. respectively, was only 1.1 degrees during the entire twenty-four hour period. This demonstrates the proficiency of the ability of the bees to maintain a very constant temperature in the central brood area when the external temperature is similar to that represented by the graph. It would seem then when comparing the central brood area temperatures with the curves rep-

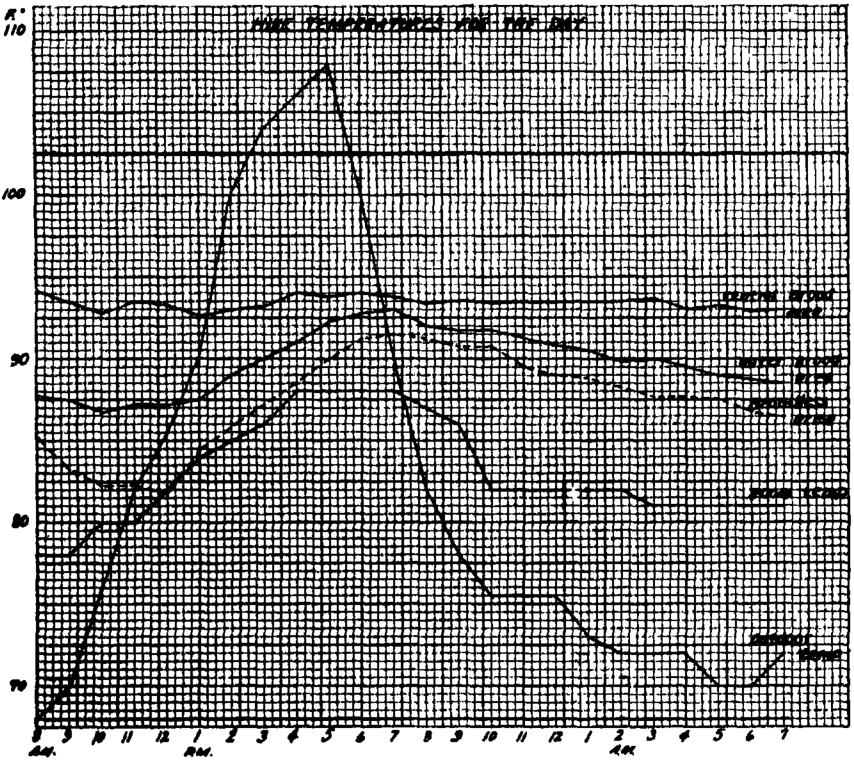
TABLE I.

HIVE TEMPERATURES FOR EACH HOUR OF THE DAY.

July 28, 1926	Av. Temp. Central Brood Area	Av. Temp. Outer Brood Area	Av. Temp Brood-less Area	Room Temper-ature	Outdoor Temper-ature
8:00 A M.	94.1° F.	87.7° F.	85.2° F.	78° F.	68° F.
9:00	93.5	87.5	83.2	78	70
10:00	92.8	86.7	82.2	80	76
11:00	93.5	87.2	82.2	80	82
12:00	93.2	87.2	81.7	82	86
1:00 P M.	92.6	87.5	84.5	84	90
2:00	93	89	85.7	85	100
3:00	93.2	90	87.2	86	104
4:00	94	91	88.5	88	106
5:00	93.7	92.2	90	88	108
6:00	94	92.7	91.2	88	100
7:00	93.7	93	91.5	88	90
8:00	93.4	92	91.2	87	82
9:00	93.5	91.7	90.7	86	78
10:00	93.4	91.7	90.7	82	76
11:00	93.5	91.2	89.5	82	76
12:00	93.5	90.7	89	82	76
1:00 A. M.	93.5	90.5	88.9	82	73
2:00	93.5	89.7	88.2	82	72
3:00	93.6	90	87.7	81	72
4:00	93	89.5	87.7	81	72
5:00	93.2	89	87.5	81	70
6:00	92.8	88.7	86.7	81	70
7:00	93	88.5	86.5	81	72

resenting external environmental temperatures that there was only a slight, if any, correlation between the temperatures occurring in the central brood area and external temperatures.

The curve representing the hourly temperatures in the outer brood area is extremely interesting as it shows that the temperatures in this region are quite distinct from those occurring in the central brood area. The temperatures of the outer brood area most nearly approach those of the central brood area when the environmental temperatures to which the colony is subjected reach their highest level. With the gradual lowering of the external temperatures, as indicated in the graph, there is a greater deviation between these two curves. Stating this more directly when comparing the curve of the outer brood area with the curves representing the environmental temperatures, the temperature fluctuates to a certain extent with the rise and fall of external temperatures, such as occurred in this experiment.



AUGUST 28, 1926

FIG. 1

The temperatures recorded hourly in the broodless area are the lowest of any region of the hive and when comparing this curve with the environmental temperature curves, it seems to be influenced to the greatest extent.

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THE HYPSOMETRIC MAP VERSUS THE PROJECTED PROFILE METHOD IN PROTRAYING AND DETERMINING EROSION SURFACES.

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In the past, two methods have been used to determine erosion levels, the hypsometric and profile methods. The question arises as to which is the better. In the hypsometric plan the erosion surfaces are determined by coloring in, on a topographic map, all the points at a definite elevation or approximately that. Various colors are used to differentiate the levels. The disadvantages of using the hypsometric method are many. A peneplane or erosion surface is not a level one, but rolling, rising toward the divides and descending toward the streams and their outlets. Even in the penultimate stage of the cycle of erosion, a peneplane would vary considerably in elevation; in the case of the Schooley (Kittatinny) surface in eastern Pennsylvania, a difference of more than 300 feet. To attempt to color in an undulating, peneplaned surface, varying several hundred feet in elevation seems impossible. The danger lies in getting too many erosion surfaces. The point is, that one undulating, peneplaned surface might easily be misinterpreted as several.

In the determination of any peneplane surface it is necessary to consider the hardness of the rock, the composition of the rock, distance from major streams, width of rock outcrop, thickness of the formation and temporary base levels. These factors, even in the penultimate stage of the cycle of erosion, should be considered. Sloping surfaces on a peneplane do not show up on a hypsometric map. Furthermore, it is very difficult, if not impossible, to picture in one's mind's eye the topography as colored in on a series of contour maps. Another serious objection to the hypsometric map is that when it is completed, even though it covers a comparatively small area, it is too large to be published. When a considerable area is reduced to a size suitable for publication, much of the detail must necessarily be eliminated. It is difficult to gain a proper conception of a peneplane or erosion surface by means of a hypsometric map.

One of the first to use projected profiles in determining erosion levels was Joseph Barrell[1]. More recently, Douglas Johnson of Columbia, Frank Wright of Dennison and the author have used projected profiles in connection with their work in the Appalachian region. In this method, the area to be projected is outlined on the topographic map. The topography is systematically projected onto cross-section paper with the aid of a T-square. Ordinarily the highest points in any belt of definite width are plotted and a line connecting them gives the profile. The narrower the belt projected, the more accurate the results and the broader the area projected the greater the amount of concealed lowland. Where one wishes to construct profiles of erosion surfaces it is more desirable to have a projection of the entire area than of a limited area, only that covered by the lines along which linear profiles are made.

The major disadvantage of the projected profile is that some of the lower points are concealed by the higher areas. But this can be eliminated to a large degree by projecting a narrower area. Upon the completion of the profiles on cross-section paper they can be transferred to heavy cardboard. It is then possible to cut them out and by means of supports they can be placed in the proper position to be photographed.

A modification of the projected profile method has been used by Miss Cornish[2]. The projected profiles were transferred to glass. The resulting transparencies were then assembled in exact register and viewed by transmitted light. This method provides a test by which it may be determined whether the hidden, lower elevations invalidate any determination based on results obtained by the regular projected profile method. The only difficulty here is that in case of a large number of profiles the result appears to be a confusion of intersecting lines, difficult to interpret. Furthermore, this method does not give perspective, the effect of depth as well as height and breadth. On the whole, the regular projected profile method, in the opinion of the writer, is superior to any yet devised to depict erosion surfaces.

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[1] Barrell, Joseph. "The Piedmont Terraces of the Northern Appalachians," *American Journal of Science*, 4th series, Vol. 49, 1920.

[2] *Journal of Geology*, Vol. 37, No. 2, p. 117.

OBITUARY.

PHILIP ROSEMOND LOWRY, M. Sc.

Philip Rosemond Lowry, B. Sc., Ohio State University, of 1920, died at Durham, New Hampshire, April 29, 1931.

From accounts received at the University it appears that he suffered a heart attack and his death was sudden and unexpected. "Phil" Lowry was an outstanding student while in the University, a great favorite with teachers and associates, combining a virile activity and brilliant intellect with a delightful personality which resulted in many friendships. In his chosen work in entomology he showed great promise and after taking his Master's degree in 1921 he received an appointment in the University of New Hampshire under Professor W. C. O'Kane (class '97). In this position he had been rapidly advanced in the work of the department and was at the time of his death ranked as Assistant Professor.

He was a member of the American Association for the advancement of Science, the American Association of Economic Entomologists, the Entomological Society of America, the Ecological Society of America, the Ohio Academy of Science and other scientific societies.

He was born September 24, 1896 and his death in his 35th year on what seems the threshold of a brilliant career in science is a heavy blow to a host of admiring friends and associates.

—HERBERT OSBORN.

BOOK REVIEWS.

DEMONS OF THE DUST. By WILLIAM MORTON WHEELER. W. W. Norton & Company, Inc , Publishers, New York.

Doctor Wheeler has brought together under this rather striking title a very interesting collection of studies upon certain groups of insects which have developed very striking habits in securing their food.

There is an interesting chapter on "Some Eighteenth Century Naturalists," treating of certain writers who presented the results of their studies of these insects; a chapter on "The Fauna of the Sands," giving a general survey of adaptation to arid conditions, then a series of chapters reviewing studies of different dust or sand inhabiting species with a quite complete monograph of the genus *Lampromyia*. Appendices include translations of early papers by De Geer and Réaumur. There is an extended and very complete bibliography.

The book is written in Doctor Wheeler's very interesting style and the illustrations and descriptions are evidently of his usual exact and illuminating character. The book will appeal to a wide circle of readers, both on account of its entertaining style and the remarkable habits of the insects treated.

REPORT ON THE GAME SURVEY OF THE NORTH CENTRAL STATES. By ALDO LEOPOLD. For the Sporting Arms and Ammunition Manufacturers' Institute Under the Direction of its *Committee on Restoration and Protection of Game.*

This exhaustive report, while intended especially for those interested in game protection, includes many features that will be of interest to conservationists, especially to those interested in the preservation of wild life in as nearly as possible native conditions.

It includes surveys of the central northern states, Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa and Missouri and treats of the principal game birds and animals, many of them being species which are in danger of serious reduction or extermination. It includes numerous maps and charts and tabulated results of field studies. Copies are obtainable from American Game Association, Investment Bldg., Fifteenth and K Streets, Washington, D. C., at $1.00 each, postpaid.

EXPERIMENTS IN ATOMIC SCIENCE FOR THE AMATEUR. By JAMES L. CLIFFORD. Published by Richard G. Badger, Boston, Mass.

This work is intended to give simple directions for the performance of experiments by amateurs and deals particularly with radio activ substances, atomic structure, electrons, osmosis and ultra violet ligh A brief bibliography is included.

H. O.

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'31. REID, W. M., *Botany, Entomology, Geology* .. 155 E. Union St., Circleville
'26. RENSHAW, SAMUEL, (F '30), *Psychology,*
Dept of Psychology, O. S. U., Columbus
'01. RICE, EDWARD L., (F '20), *Zoology* . .. . . O. W. U., Delaware
'30. RICHARDS, ELIZABETH PUTNAM, *Geology, Geography* 271 Forest St., Oberlin
'31. RIDDELL, NEWTON N., *Psychology, Biology* . .. . P. O. Box 408, Lima
'31. RIECKEN, WILLIAM E., *Botany* .. .. 1018 N. Washington St., Kokomo, Ind.
'28. RIELLEY, LENDELL CHARLES, *Psychology*.. Wilberforce University, Xenia
'21. RILEY, C. L., *Biology, Geology* . . .... 1226 Fourteenth St. N. W., Canton
'30. RING, DEWITT T., *Geology, Paleontology, Geography,*
99 N. Front St., Columbus
'31. ROACH, LEE S., *Zoology, Animal Ecology*. .... Athens
'30. ROBERTSON, L. A., *Botany*... ....427 E. Fourteenth Ave., Columbus
'14. ROBINSON, J. M., *Entomology*... . ....Box 247, Exp. Sta., Auburn, Ala.
'19. ROGERS, A. SOPHIE, (F '27), *Psychology*. ....52 E. Pacemont Rd., Columbus
'13. ROGERS, CHARLES G., (F '20), *Physiology*...378 Reamer Place, Oberlin

'14. Rood, Almon N., *Botany* .... R. F. D. No. 2, Phalanx Station
'21. ROOTS, YALE K., *Physics* . 100 Washington Square E., New York City
'25. Roth, Conrad, *Ornithology, Botany, Forestry*, 1715 Robinson Ave., Portsmouth
'25. Rowles, Emmett, *Zoology, Medical Sciences* ... 97 Franklin Ave., Athens
'22. RUNNELS, HARMON A., *Botany*, Ohio Agricultural Experiment Station, Wooster

'18. SAMPSON, HOMER C., (F '20), *Botany* .... O. S. U., Columbus
'28. Savage, John R., *Entomology, Zoology, Ecology*, Ohio Agricultural Experiment Station, Wooster
'31. Sawyer, Dr. Carl W., *Medical Sciences* .... White Oaks Farm, Marion
'21. Sayre, Jasper D., (F '22), *Botany*, Ohio Agricultural Experiment Station, Wooster
'31. Schaefer, Frances, *Geology* .... 383 Oakland Park Ave., Columbus
'27. Schaefer, J. E., *Geology, Mineralogy* .... 13212 Superior St., Cleveland
'97. SCHAFFNER, JOHN H., (F '20), *Botany* .. O. S. U., Columbus
'13. SCHEAR, E. W. E., *Biology* .... 107 W. Park, Westerville
'07. SCHEFFEL, EARL R., *Geology* . 326 W. Nassau St., St. Peter, Minn.
'30. Schmidt, Jacob J., *Geology* .... East Ohio Gas Co., Cleveland
'27. Schneider, Elizabeth, *Biology* . 514 N. Wittenberg Ave., Springfield
'31. Schoff, C. N., *Geology* .... 61 S. Professor St., Oberlin
'29. SCHOFF, STUART L., *Geology* .... 1590 Neil Ave., Columbus
'25. SCOTT, JOSEPH M., *Bacteriology, Animal Parasitology*, 1415 Inwood, Alliance
'31. Scott, Thurman C., *Psychology* .... 34½ N. Congress St., Athens
'25. SCOTT, LUTHER C, *Geology* .... Toledo University, Toledo
'15. SEARS, PAUL B., (F '21), *Botany, Entomology*, University of Oklahoma, Norman, Okla
'26. Seashore, Robert H., *Psychology* .... 958 E. 21st St., Eugene, Ore.
'22. Secrest, Edmund, (F '24), *Forestry*, Ohio Agricultural Experiment Station, Wooster
'28. Segelken, John G., *Botany*, Fairmount Ave., Burnham Park Estates, Morristown, N. J.
'26. Selbert, (Mrs.) Norma, *Medical Sciences*, Hamilton Hall, O. S. U., Columbus
'14. SEYMOUR, RAYMOND JESSE, (F '20), *Physiology, Zoology, Botany*, Dept. of Physiology, O. S. U., Columbus
'12. SHADLE, ALBERT, *Zoology*, Dept. of Biology, University of Buffalo, Buffalo, N. Y.
'31. Sharp, Henry S., *Geology* .... Granville
'11. Sharp, Mrs. Katharine Dooris, (F '28), *Botany, Geology* .... London
'08. SHATZER, C. G., (F '20), *Geology, Geography*, 1003 Woodlawn Ave., Springfield
'30. Shelton, G. R., *Geology and Physical Sciences*, Bureau of Standards, Lord Hall, O. S. U., Columbus
'31. Shenker, Samuel, *Chemistry* .... 649 Lilley Ave., Columbus
'15. Shetrone, H. C., ('29), (F '31), *Archaeology*, Ohio State Museum, Columbus
'13. SHIDELER, W. H., (F '20), *Geology* .... Miami University, Oxford
'29. Shuman, Helen Woodburn, *Geology, Psychology* .... Salesville

'15. Shuman, S. C., *Botany*.................................Greenwich
'13. Shuman, W. L., *Botany* ....South Euclid
'31. Simonton, Owen W., *Geology*..... Room 12, Quinby Bldg., Wooster
'28. Simpson, Walter, *Medical Science, Pathology*,
Miami Valley Hospital, Dayton
'28. SLAGG, RODNEY A., *Botany, Geology* .....433 E. Buchtel Ave., Akron
'31. Slavens, Margaret D., *Geography, Geology*,
Muskingum College, New Concord
'29. Sleesman, George B., *Botany, Entomology* . S. Union St., Ada
'27. Sleesman, J. P , *Zoology, Entomology*,
Ohio Agricultural Experiment Station, Wooster
'12. SMITH, ALPHEUS W , ('22; F '22), *Physics*. O. S. U. Columbus
'16. SMITH, CLAYTON S., *Medical Sciences*, Hamilton Hall, O. S. U., Columbus
'21. SMITH, ERNEST RICE, (F '21), *Geology, Paleontology*,
309 Greenwood Ave., Greencastle, Ind.
'30. Smith, Floyd F , *Entomology, Zoology, Botany*,
Arlington Farm, Rosslyn, Va
'30. Smith, Guy Harold, *Geography and Geology*,
Dept of Geography, O. S. U., Columbus
'29. Smith, Isabel Seymour, *Botany* 145 Woodland Ave., Oberlin
'31. Smith, J. J., *Social Psychology* 109 Lakeside, New Concord
'27. SNIDER, GEORGE GOULD, *Zoology, Medicine, Botany* Address unknown
'02. SNYDER, F. D., *Zoology, Ethnology* 235 Main St., Ashtabula
'31. SNYDER, LAWRENCE H., *Zoology, Genetics*,
Dept. of Zoology, O. S. U., Columbus
'29. Spahr, George T. (**), *General Science* .514 E. Town St., Columbus
'22. Spencer, Herbert, *Entomology, Zoology, Ecology*,
Louisiana Experiment Station, Baton Rouge, La.
'25. SPENCER, WARREN P., (F '29), *Zoology* 702 College Ave., Wooster
'26. SPIEKER, EDMUND M., (F '27), *Geology*, Orton Hall, O. S. U., Columbus
'18. Spohr, Carl F., (F '20), *Medical Sciences*, Medical Dept., O. S. U., Columbus
'31. Squires, G. R., *Geology, esp. Coal Formation Fossils*,
4092 Mayfield Rd., South Euclid
'29. Squires, H. D., *Geology* . ... Orton Hall, O. S. U., Columbus
'29. Stannard, J. Newell, *Geology, Chemistry*... .65 N. Pleasant St., Oberlin
'31. Stark, Orton K., *Botany* .. .. .Oxford
'05. STAUFFER, CLINTON R., (* F '20), *Geology*,
University of Minnesota, Minneapolis, Minn.
'31. Stehr, William C., *Zoology, Entomology*,
Biology Dept., Ohio University, Athens
'30. Stephenson, Leonard L., *Botany and several branches of Biology* ...Buchtel
'31. Stetson, Harlan True, *Physical Sciences*,
Perkins Observatory, O. W. U., Delaware
'25. Stewart, Grace A., (F '27), *Geology* .... O. S. U., Columbus
'08. STICKNEY, M. E., (F '20), *Botany*....... Denison University, Granville
'22. STOCKDALE, PARIS B., (F '24), *Geology*,
Dept. of Geology, O. S. U., Columbus
'20. STONE, JULIUS F., *General Science* .... Grandview, Columbus
'31. Stone, Robert Granville, *Geography, Physiography, Geology*,
229 W. Eleventh Ave., Columbus

'26 STOUT, GILBERT LEONIDAS, *Botany, Genetics*, State Dept. of Agriculture, Sacramento, Calif.
'15 Stout, Harry O , *Botany, Geology, Agriculture, Zoology*, Bowling Green High School, Bowling Green
'08 STOUT, W. E , (F '20), *Chemistry, Ceramics, Geology*, 154 Erie Road, Columbus
'20. STOVER, ERNEST L , (F '30), *Botany*, Eastern Illinois Normal College, Charleston, Ill.
'09. STOVER, W. G , (F '20), *Botany, Plant Pathology* O S U., Columbus
'29. Stupka, Arthur, *Nature Study* .. 66 W Tenth Ave , Columbus
'30. Surrarrer, Thomas, *Zoology* . . . R. F D. No 1, Berea
'29. Swingle, Mary, *Biology* . . Box No 32, Philo
'23. SWINNERTON, ALLYN C., (F '27), *Geology*, Antioch College, Yellow Springs

'28. TASHIRO, SHIRO, (F '29), *Medical Sciences, Chemistry*, University of Cincinnati, Cincinnati
'31 Taylor, Dr. A. M., *Botany, Zoology, Forestry, Horticulture, (any Biological Science)* . Lake Erie College, Painesville
'19. Taylor, Mrs. Bayard, *Botany, Ornithology* .. . West Jefferson
'25. TAYLOR, L. W., (F '29), *Physical Sciences* . 30 N. Pleasant St , Oberlin
'26. TEDESCHE, LEON G . 416 Catherine St , Cincinnati
'25. TERWILLIGER, CHARLES VAN ORDEN, *Physical Sciences*, 186 Gloucester St , Annapolis, Md
'28. THEIS, CHARLES V., (F '29), *Geology*, University of Cincinnati, Cincinnati
'25. Thiessen, Norman W., *Chemistry, Biology*. 160 Kent St., Brookline, Mass.
'19. Thomas, Edward S., *Ornithology*, Ohio Archaeological and Historical Museum, O. S. U., Columbus
'15. THOMAS, ROY C., (F '23), *Botany, Zoology, Geology*, Ohio Agricultural Experiment Station, Wooster
'25. Thompson, Oscar E., *Zoology, Botany*. 140 E. Fifteenth St., Holland, Mich.
'26 THUT, HIRAM F., *Botany* . . . . 1501 Neil Ave., Columbus
'30. Tidd, Wilbur M., *Zoology* Botany and Zoology Bldg., O. S. U., Columbus
'20. TIFFANY, LEWIS H. (F '23), *Botany*, Dept. of Botany, O. S. U., Columbus
'94. TODD, JOSEPH H. (F '25), *Geology, Archaeology*, Christmas Knoll, Wooster
'19. TOOPS, HERBERT A. (F '24), Dept. of Psychology, O. S. U., Columbus
'19. TOOPS, LAURA CHASSELL, *Psychology*. 458 W. Eighth Ave., Columbus
'15. TRANSEAU, EDGAR N. (F '20), *Botany*.. ... O. S. U., Columbus
'26. Trautman, Milton B., *Ornithology*... . ... 618 S. Fifth St., Columbus
'19. TRETTIEN, A. W., *Psychology* . . .. Toledo University, Toledo
'30. Troyer, Maurice E., *Psychology* . ...Bluffton College, Bluffton
'29. TUCKER, FORREST G., (F '31), *Physics, Mathematics, Chemistry*, 99 S. Cedar St., Oberlin
'12. TURNER, CLARENCE L., (F '20), *Zoology*, Northwestern University, Evanston, Ill.
'29. TWITCHELL, GEORGE B., (F '30), *Geology, Medical Sciences*, 845 Dayton St., Cincinnati

'31. Uhrbrock, Richard Stephen, *Psychology*, Statistical and Research Dept., The Procter & Gamble Co., Cincinnati

'30. Ullman, Roy R., *Psychology* . ...227 Ferrell Ave., Ashland
'30. University of Cincinnati, *Library*. ... . Cincinnati

'26. Valentine, Willard L., *Psychology* 346 Olentangy St., Columbus
'30. Van Cleef, Eugene, *Geography, Climatology,*
Dept. of Geography, O. S. U., Columbus
'15. VAN CLEVE, M. R., *Physical Geography, Botany,*
Board of Education, Toledo
'21. VAN HORN, FRANK R., (* F '22), *Geology,*
Case School of Applied Science, Cleveland
'23. VAN HORN, JESSE LOWER, *Chemistry, Physics,*
1490 Roycroft Ave., Lakewood
'31. Varvel, Carl Dudley, *Geography, Ethnography,*
Dept. of Geography, O. S. U., Columbus
'24 VER STEEG, CARL, (F '31), *Geology, Geography* 1030 Spink St., Wooster
'30. Vinal, W. G. . Western Reserve University, Cleveland
'26. VISSCHER, J. PAUL, (F '29), *Biology, Zoology, Medical Sciences,* ·
Western Reserve University, Cleveland
'15 VIVIAN, ALFRED, (F '20), *Agriculture, Chemistry* O. S. U., Columbus
'30. Von Ohlen, Floyd W., *Botany* Botany Dept., O. S. U., Columbus
'28. VON SCHLICHTEN, OTTO C., (F '29), *Geology,*
University of Cincinnati, Cincinnati

'04. WAITE, F. C., (F '20), *Anatomy, Zoology* 2109 Adelbert Road, Cleveland
'27 Walker, Charles F., *Ornithology* 53 Latta Ave., Columbus
'18. WALLER, A. E., (F '20), *Botany,*
Botany and Zoology Bldg., O. S. U., Columbus
'02. WALTON, L. B., (F '20), *Biology* Kenyon College, Gambier
'30. Warner, David Clark, *Geography, Geology and Topograph, with special reference to Water Conservation* .....248 Pasadena Ave., Camp Chase
'30 Warner, Edward N., *Ichthyology, Botany, Histology,*
Botany and Zoology Bldg., O. S. U., Columbus
'30. Watson, D. A., *Biology, Botany and General Science* .. Batesville
'27. Webster, Charlotte E., *Geology, Botany, Ecology,*
300 Washington Ave., Elyria
'29. Weed, R. B., *Geology* . 805 Buckeye Bldg., Columbus
'31. Weir, Kenneth J., *Entomology, Zoology, Botany,* R. F. D. No. 3, Ashtabula
'31. Welch, Winona H., *Botany,*
Dept. of Botany, DePauw University, Greencastle, Ind.
'11. WELLS, B. W., (F '21), *Botany,*
North Carolina Agricultural College, Raleigh, N. C.
'24. WELTON, F. A., *Agronomy,*
Ohio Agricultural Experiment Station, Wooster
'91. **Werner, William C.**, ('22), *Botany* . . . . 352 N. St. Clair St., Painesville
'01. **Westgate, Lewis G.**, (F '20), *Geology* . . 124 Oak Hill Ave., Delaware
'24. **White, George W.**, *Geology,*
Dept. of Geology, University of N. H., Durham, N. H.
'28. **White, Monica**, *Zoology, Botany* . . . . . . 100 Center St., Struthers
'18. WICKLIFF, E. L., (F '23), *Zoology, Ornithology,*
Fish and Game Division, State House, Columbus

'25. WIEBE, ABRAHAM H., *Biology*. .21 S. Biological Station, Fairport, Iowa
'25. Wilcox, R. B., *Botany*. . . . . .Whitesbog, N. J.
'22. WILLARD, C. J., (F '24), *Agronomy, Botany*. . . . . O. S. U., Columbus
'25. WILLIAMS, C. G., *Botany*, Ohio Agricultural Experiment Station, Wooster
'21. Williams, R. D., *Philosophy, Psychology*,
Dept. of Philosophy, O. S. U., Columbus
'03. WILLIAMS, STEPHEN R., (F '20), *Biology*. . . .300 E. Church St., Oxford
'97. WILLIAMSON, E. B., (F '31), *Entomology*. . . . . Bluffton, Ind.
'24. WILSON, IRA T., *Zoology*. . . . . .Heidelberg University, Tiffin
'26. WILSON, ORVILLE TURNER, (F '31), *Botany, Bacteriology, Plant Pathology*. . . . . University of Cincinnati, Cincinnati
'30. Wing, David Grant, *Biology and Chemistry*,
Dept. of Geology, Miami University, Oxford
'26. Winnette, Clifford L., *Geology, Chemistry*, R. F. D. No. 2, Canonsburg, Pa.
'29. Winston, Mattie, *Geology*. . . . . 2314 Sauer Ave., Cincinnati
'15. WITHROW, JAMES R., (F '20), *Chemistry, Mineralogy*,
Chemical Engineering Dept., O. S. U., Columbus
'31. Withrow, Robert B., *Plant Physiology*, University of Cincinnati, Cincinnati
'29. WOLFE, RICHARD E., *Biology, Physics, Chemistry*,
108 E. Maple St., Clyde
'30. Wolford, J. J., *Geology*. . . . . .Care of T. C. Wolford, Xenia
'29. Wolfram, George, *Ornithology, Nature Photography*,
1507 Michigan Ave., Columbus
'31. WOOD, C. C., *Psychology* . . . . .University of Akron, Akron
'30. Wright, Alfred J., *Geography, Economics*,
Commerce Bldg., O. S. U., Columbus
'26. WRIGHT, FRANK J., (F '29), *Geology* . . .Denison University, Granville
'29. WUESTNER, HERMAN, *Mineralogy*. . .3335 Cavanaugh Ave., Cincinnati
'20. WURDACK, MARY E., *Botany*. . . . . .68 Chatham Road, Columbus

'03. YORK, HARLAN H., *Botany*,
Dept. of Botany, University of Pennsylvania, Philadelphia, Penna.
'27. Young, Boyd B., *Biology, Zoology*. . . . . .18 W. Perrin Ave., Springfield
'24. YOUNG, H. C., (F '26), *Botany*,
Ohio Agricultural Experiment Station, Wooster
'31. Young, Irvin F., *Botany, Zoology, Chemistry*. .908 S. Ohio Ave., Columbus
'31. Yowell, Everett I, *Astronomy, Mathematics* .3127 Griest Ave., Cincinnati

'29. Zurcher, Esther R., *Biological Sciences*,
Dept. of Zoology, O. S. U., Columbus
'31. Zwick, Dr. Karl G., *Medical Sciences*. . . . . .Doctors' Bldg., Cincinnati

REPORT OF FORTY-FIRST ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE.

WILLIAM H. ALEXANDER,
Secretary

INTRODUCTORY.

The Forty-first Annual Meeting of THE OHIO ACADEMY OF SCIENCE took the form of a very delightful tri-state meeting, the Academies of Indiana and Kentucky joining enthusiastically with the Ohio Academy in a two-day gathering on the historic campus of old Miami University at Oxford, Ohio. The setting and atmosphere of Old Miami could scarcely be excelled for such a gathering. The reception was cordial, the provisions for the comfort of visitors ample and satisfying, and the many mechanical and other requirements of the various scientific sessions wonderfully anticipated and provided for by the several local committees under the general and able supervision of Prof. Arthur T. Evans.

The Ohio Academy, certainly the Section of Physical Sciences, was further honored by the presence and participation of many members of the Central Ohio Physics Club and of the Akron Physics Society. The Academy welcomes these organizations and views such affiliation with high favor, sincerely hoping it will become stronger and closer with the passing years.

Somewhat in the nature of an experiment, the program committee made a very commendable and successful effort to provide intellectual and social entertainment for Thursday arrivals. A field trip under the guidance of Prof. William H. Shideler of Miami University was arranged for the afternoon for all who arrived in time and an informal program consisting mainly of an illustrated address by Dr. F. O. Grover of Oberlin College on "Traces of Early Man in Western Europe" was provided for the evening following the dinner hour. After the lecture, a delightful social hour was spent in the spacious lounge room of Ogden Hall. This innovation seems to have met with considerable favor and ought in the future to be a real inducement to go early for old and new acquaintance's sake.

The first formal meeting of general interest was that of Friday morning when the three presidents of the participating academies were introduced and gave an address. President Foerste of the Ohio Academy spoke on the "Ancient Life of the Arctic," President Davis of the Indiana Academy, on "Points of Historical and Scientific Interest in Indiana," (illustrated); and President Payne of the Kentucky Academy on, "An Optimistic View of the Evolution of Sciences."

Following these scholarly addresses, came a second innovation introduced by the program committee, namely, the giving of a definite and exclusive time for members to visit and enjoy the exhibits and demonstrations provided by members, often at considerable expense of time and energy. This innovation met with general favor and many were the expressions of pleasure and surprise at the variety, the number and general excellence of this feature of the annual program, really known to many for the first time.

The next event of general interest was the annual banquet on Friday evening in Ogden Hall dining room, which proved to be something of a surprise, especially in the matter of attendance which came near overtaxing the dining hall facilities. More than 300 reservations were made and still they came. Following a very delicious repast, the occasion was taken in hand by Prof. Robert A. Hefner, of Oxford, who as toastmaster guided the post-prandial exercises in a very skillful, interesting manner. He first introduced President Upham, of Miami University, who in a most gracious manner extended words of welcome to the several participating organizations and then followed these with some very happy, helpful observations on "Removing Partition Walls." The toastmaster then introduced, beginning with Kentucky, the presidents of the three academies, also the president or representative of each of the physics clubs participating in the meeting, each of whom made response to the welcoming words of President Upham and added his bit of wit. Then followed several delightful musical selections by local talent and then some more talk on "L. O. K." (the Lord only knows) by Professor Dan Sullivan, of Miami University—anecdotes told in a rapid-fire fashion that kept the audience in a continuous uproar of laughter! The banquet was a great success despite the unexpected numbers.

A third innovation introduced by the program committee was the reduction to a minimum of the time given to the business and general scientific session, the emphasis being decidedly on the sectional programs and meetings. Only two business meetings, one of a half hour on Friday morning and the other of three-quarters of an hour on Saturday morning were held and but one general scientific session, namely, on Friday morning, lasting an hour and a half.

Judged by any of the usual standards, the second Oxford meeting was a gratifying success.

MINUTES OF THE BUSINESS MEETINGS.

First Session: April 3, 1931.

The first business session of the Forty-first Annual Meeting of the Ohio Academy of Science was held in McGuffey Hall, room 210, and was called to order by President Foerste at 9:00 A. M., Friday, April 3, 1931, with a quorum present.

The President announced the following committee appointments:

Committee on Membership—Ralph V. Bangham, E. W. E. Schear and W. H. Shideler.

Committee on Resolution—J. Paul Visscher, E. H. Johnson and E. Lucy Braun.

Committee on Necrology—Clarence H. Kennedy and Edward S. Thomas.

The reports of the Secretary and Treasurer were then called for and read. The report of the Secretary was accepted and ordered filed. The report of the Treasurer was referred to the auditing committee. Both reports are published elsewhere in these proceedings.

The Academy then proceeded to the election of an Auditing Committee, resulting in the election of J. E. Hyde and E. L. Rice.

The election of a Nominating Committee was then called for but owing to lack of time and the further fact that this committee is not expected to report until next year, the Secretary suggested that the election be postponed until the next meeting and be taken up at the same time as the general election of officers. There being no objection the election was postponed as suggested.

New business was then called for. There being none the reports of standing committees were called for and read as follows:

For the *Executive Committee*, by the Secretary.

For the *Publications Committee*, by F. O. Grover, Chairman.

For the *Trustees of the Research Fund*, by Herbert Osborn, Chairman.

For the *Committee on State Parks and Conservation*, by Herbert Osborn, Chairman.

At this point (about 9:40 A. M.) the Secretary called attention to the fact that the business meeting had already transgressed upon the time of the sectional meetings and moved to adjourn to 8:45 A. M. Saturday, April 4, 1931. Motion carried.

Second Session: April 4, 1931.

The second or adjourned session of the Academy met as per adjournment at 8:45 A. M., April 4, 1931, again in room 210, McGuffey Hall and was promptly called to order by President Foerste, with a quorum present.

The first item of business was the report of the Library Committee, passed over at the first session owing to the absence of the chairman when called. The report was read by Mrs. Ethel M. Miller, chairman, and is printed in full elsewhere in this report. The services of Mrs. Miller as chairman of the Library Committee constitute one of the most outstanding features of the year's work. Her work deserves and is receiving the hearty commendation of the Academy.

Following the report of the Library Committee, reports of Standing Committees were read as follows:

For the *Committee on Election of Fellows*, by the Secretary.
For the *Membership Committee*, by Ralph V. Bangham, Chairman.
For the *Necrology Committee*, by Clarence H. Kennedy, Chairman.
For the *Special Committee on Junior Scientific Effort in Ohio*, by C. G. Shatzer, Chairman.
For the *Special Committee on the Academy's Relation to the Ohio Journal of Science*, by J. E. Hyde, its Secretary, at the request of E. L. Rice, Chairman.
For the *Committee on Nominations*, by Edward L. Rice, Chairman.

All the above reports were received, ordered filed and are published in full elsewhere in these proceedings.

The following names were then placed in nomination for the *Nominating Committee* to make a report a year hence, viz: For *Zoology*, Wencel J. Kostir; *Botany*, J. Hobart Hoskins; *Geology*, Frank J. Wright; *Medical Sciences*, Charles G. Rogers; *Psychology*, James P. Porter; *Physical Sciences*, L. W. Taylor.

There being no other nominations, a motion was duly made and agreed to that the Secretary cast a written ballot for the persons mentioned which was done and they were declared elected.

In connection with the report from the Committee on Junior Scientific Effort in Ohio, Chairman Shatzer pointed out some of the inherent difficulties of the task and further stated that the work could not be successfully prosecuted without incurring some expense and requested an appropriation of $50.00 for this work during the coming year. Upon motion, duly made and passed, the committee was authorized to expend a sum not to exceed $50.00 in the discharge of its duties during the ensuing year.

Following the report of Necrology Committee, Prof. James P. Porter read a telegram just received announcing the death this morning of Prof. A. P. Weiss, a member and former president of this Academy, and then moved that the following message be sent to the bereaved family, viz:

> "Members of the Ohio Academy of Science in annual meeting assembled wish to express to you and your family their sincere sympathy in your present loss. As a former President of the Ohio Academy of Science and Vice-President of the Section of Psychology, as research worker, teacher and friendly associate, Doctor Weiss will long be remembered and respected."

Dr. L. W. Taylor, of Oberlin College, offered the following resolution which was unanimously agreed to:

> "The Ohio Academy of Science expresses its regret that consideration of House Bill Number 276 has not been found advisable. The Academy endorses the humanitarian features of that bill which proposes to reduce the very serious and unnecessary suffering by animals caught in steel traps. The practicability of trapping fur-bearing animals by methods that will either kill quickly or will catch animals uninjured is a matter of common knowledge. But use of these more expensive traps cannot become common until the common steel trap is outlawed. For this reason the Ohio Academy favors legislation outlawing the steel trap."

The selection of the Academy representative on the Council of the American Association for the Advancement of Science and the State Academies Conference, the selection of the next place of meeting and time, and the election of two representatives on the Save Outdoor Ohio Council were referred to the Executive Committee with power.

At 9:35 A. M. the business session was adjourned *sine die*.

SUPPLEMENTAL TO THE MINUTES OF THE BUSINESS SESSIONS.

Important Miscellaneous Notes.

1. From the *Executive Committee:* At the final meeting of the Executive Committee, Dr. Edward L. Rice, a member of the committee, raised the question as to why it would not be advantageous to the Academy to select as the *Nominating Committee* for the ensuing year the vice-presidents of the current year, thus utilizing the experience and knowledge gained by the year's service as vice-presidents. The suggestion was favorably received by the Executive Committee and was passed on to the present Nominating Committee which, as may be observed, approved and followed the suggestion. The Executive Committee, of course, recognizes that it has no authority to place limitations on the Academy in the matter of electing its officers and committeemen, nor has it any desire to do so. The suggestion of Doctor Rice is simply placed on record for future reference.

2. From the *Committee on the Election of Fellows:* On account of last-minute nominations, resulting in hasty and sometimes premature action on the part of the committee, the committee, at the suggestion of Dr. F. C. Waite, put itself on record as follows:

> "That the secretary be requested to prepare new blanks on which to make nominations to Fellowship and that it be definitely stated on the new blanks that all nominations to Fellowship must be in the hands of the Secretary at least 60 days before the Annual Meeting at which the nominations are to be voted on; and further, that the new blanks provide space in which to enter the societies of which the nominee is a member and how long a member of each."

Members submitting nominations to Fellowship hereafter will do well to note and follow the policy above outlined.

3. From *President Davis, Indiana:*

DEAR MR. ALEXANDER:

It was necessary for me to leave before noon last Saturday and consequently I did not have a chance to see you personally and express my appreciation as well as that of the Academy for your kindness in inviting us to meet with you and for the very excellent facilities provided.

I am sure that everyone from Indiana appreciated this opportunity and had a very enjoyable and profitable meeting.

I hope that we may have you with us at our next annual meetings.

Very sincerely yours,

JAS. J. DAVIS, *President.*

Lafayette, Indiana, April 8, 1931.

4. From the *American Ornithologists' Union:* An invitation to all members of the Ohio Academy of Science to attend the 49th States Meeting of the American Ornithologists' Union,

in the city of Detroit, during the week of October 19, 1931. "A very attractive program is being arranged and one interesting feature is a visit to Jack Miner's Bird Sanctuary, near Kingsville, Ont."

REPORTS.

Report of the Secretary.

OXFORD, OHIO, April 3, 1931.

To the Ohio Academy of Science:

Obviously an extended, detailed report by the secretary at this time would be quite out of order, owing to the severe time limitation placed upon the business sessions by the program committee. Perhaps additional details can be added to the printed report.

The usual and then some routine work of the office has been cared for as promptly and as efficiently as possible under the conditions. The service, to be sure, has not been perfect or above criticism, perhaps, but was the best we could do under the circumstances.

The Academy has grown, gathered strength, and now comes "rejoicing, bringing in the sheaves" of worthy accomplishments from the various fields of scientific endeavor, as abundantly demonstrated by the rich, varied programs before you.

We now have a total membership of 663, of whom some 89 are non-resident in Ohio, 5 being in foreign lands; 162 have been given the rank of *Fellow*, and 272 are known to be members of the American Association for the Advancement of Science (A. A. A. S).

As the duly accredited delegate, the secretary attended all the sessions of the Council and the Conference of State Academies of the A. A. A. S. at Cleveland, Ohio, last December and participated as far as possible in the discussions that came before those bodies. We were very glad to nominate and see elected to the office of secretary of the Conference of State Academies a member of this Academy, Mr. S. W. Bilsing, now of Texas. Under the rule, this means his advancement next December to the office of President of the Conference.

One item of discussion before the Conference of State Academies was the matter of exchanges, "how to get them and what periodicals are available and desirable as exchanges." We presented with very considerable pride a detailed statement by Mrs. Ethel M. Miller, chairman of our Library Committee, on this matter, and feel that same was a very substantial contribution to the discussion, so much so, in fact, that we feel justified in publishing most of her statement as a supplement to this report.

Respectfully submitted,

WILLIAM H. ALEXANDER, *Secretary.*

Supplemental to the Secretary's Report.

THE PUBLICATIONS AND EXCHANGES OF THE OHIO ACADEMY OF SCIENCE.

By MRS. ETHEL M. MILLER, *Librarian.*

The Ohio Academy of Science was organized December 31, 1891, with 59 charter members, and was incorporated March 12, 1892.

It must have received periodicals in exchange within the next few years, for we find that at its tenth annual meeting, December 26, 1900, the Trustees reported that as the Academy was coming into possession, by exchange, of many valuable reports, monographs and other papers and as it was necessary that these be kept in some proper place where they could be as accessible to the members as possible, W. C. Mills had been appointed librarian. In December, 1905, he reported that exchanges were received from 26 scientific societies and colleges. In 1909, Mr. Mills reported that the publications of the Academy were being sent to the following exchanges: Academy of Natural Sciences of Philadelphia, Brooklyn Institute of Arts and Sciences, Buffalo Society of Natural Sciences, Connecticut Academy of Arts and Sciences, Cincinnati Society of Natural History, Denison University Scientific Laboratories, Davenport Academy of Sciences, Illinois State Laboratory of Natural History, Kansas Academy of Science, New York Botanical Garden, University of California, Wisconsin Academy of Sciences, Arts and Letters, University of Missouri, Missouri Botanical Garden, Chicago Academy of Sciences, Buenos Aires National Museum, and the British Museum. These places were sending publications which he was shelving in the library of the Ohio State Archaeological and Historical Society. By 1911 the library had grown to such an extent that the librarian was authorized by the Academy to purchase cards for cataloging the library and also to publish the catalog. In 1915 the library of the Academy was deposited in the Ohio State University Library. It is available to the entire university and the members of the Ohio Academy of Science are in turn privileged to use any of the books in the University Library.

In 1915 or 1916, the Biological Club of the University gave to the University Library all the exchanges that had been received by the Ohio Naturalist from 1900 to 1915.

It is not known positively how the early exchanges were secured, but it is assumed that it was done in the same way that it is being done at present, either offered voluntarily by the other party to the exchange or sought for by us. Many letters are received, especially from foreign countries, offering their publications in return for ours, the Proceedings of the Academy, the Ohio Journal ot Science, or both. On the other hand, when we learn of some publication that we do not have or when our students, particularly the graduate students, have references to periodicals that we do not have, and we think there might be a possibility of securing them by exchange, the offer is made from here to exchange. In nearly every instance the offer is accepted, just as we usually accept offers that are made to us. Oftentimes the various societies and academies publish lists of their exchanges in an issue of their publications. This is especially true of societies in Europe and South America. These make good lists to use in order to secure additional exchanges. The recently published Union List of Serials is exceedingly helpful. Our most recent find in it was the Knox Academy of Science, which publishes the Maine Naturalist. As a result, a set of the Maine Naturalist will soon be sent to us on exchange. Very frequently the value of the publication received is much more than that of the one we send, for instance, the Philippine Journal of Science, the Journal of the Marine Biological Laboratory of the United Kingdom, the books of the British Museum, etc. On the other hand, some are priced at a lower figure than ours, so that on the whole it keeps about even. We do not aim to keep it upon a monetary basis, but this is mentioned to show that exchanges of higher value can be secured.

For our own purposes we like to know the approximate value of our exchanges to show that the University is receiving in exchanges the equivalent of the $1,000.00 it gives annually to the Ohio Journal of Science and to show that the Ohio Academy of Science is presenting to the University Library a good return for what the Library expends for postage in sending the Proceedings to the members of the Academy and to the exchanges each year and in sending back volumes on exchange. The Academy exchanges amount to about $200 00 each year and the postage, and the freight on shipments to Washington for the International Exchange Service through the Smithsonian Institution will amount to between $50.00 and $60.00. In addition, the Library pays for binding the volumes of the exchanges, usually from $2.25 to $2.50 per volume. It is also worth a good deal to have the exchanges given proper housing and care.

Available periodicals.—Those are especially available that are published by universities, institutions, scientific societies, academies, museums, and the like, particularly if they maintain libraries or are connected with institutions where they can deposit what they receive in exchange.

Desirable exchanges.—The publications of those just cited above would be especially desirable. Last year's resolution that each Academy send its publications to all the others in this country is very good for each one would certainly wish to exchange with all of them. Our own Academy has now completed arrangements to exchange with all, the Knox Academy of Science, mentioned above, and the New Hampshire Academy being the latest, unless of course there are some others that we do not know about. The New Hampshire Academy of Science plans to begin publication fairly soon and will then send to us. Some places send books instead of periodicals, as the British Museum and Cambridge University. The latter waits a number of years and then send books up to the value of the accumulated subscription price for those years. Twenty dollars' worth of books were received in 1926. In a few more years it will be suggested from here that they send another shipment to us.

The desirability of the exchanges would likely be determined by the kind of place where they were deposited. As the Ohio Academy of Science deposits in a large State University practically everything is desired and it is fitting that many things that would not be used a great deal should be shelved in our library rather than in the smaller libraries of the other universities and colleges in the State.

Relation of the Ohio Academy of Science to the Ohio Naturalist and to the Ohio Journal of Science. In November, 1900, the first issue of the Ohio Naturalist was published. As it was sponsored by men who were all members of the Ohio Academy of Science it was very natural that the Academy should adopt the Ohio Naturalist as its official organ. This was done in 1903. In 1914, the scope of the Naturalist was enlarged in view of the recently formed section of Physics in the Academy and the possible addition of other sections outside of natural science and also in view of the recent organization of the Ohio Biological Survey. The title was changed to the "Ohio Naturalist and the Ohio Journal of Science," and a year later the words "Ohio Naturalist" were dropped, retaining the last half of the new title. The Naturalist agreed to publish announcements of the meetings of the Academy, lists of publications for sale, etc., whenever the Academy desired, but such matter might be restricted to one-half page in any one issue. However, for years now the Journal has given a full page. Papers presented at the annual meetings of the Academy of from 300 to 1,500 words will be printed and the address of the President will be published in the Journal. The Journal, as was the Naturalist, is sent without additional cost to each member of the Academy not in arrears for dues. The Academy is represented on the Editorial Board of the Journal, for a time by the members of the publication committee, then by a member from each one of the various sections, but since 1926 by the retiring President and current year's President.

The Academy has always paid at least half the dues of each member to the support of the Journal, increasing from 50 cents in 1903 to 75 cents in 1906, to $1.00 in 1919, the dues increasing correspondingly, and in 1927 it decided to give $1.50 to the Journal from its dues of $2.50.

Report of the Treasurer.

(See report of the Auditing Committee.)

Report of the Executive Committee.

OXFORD, OHIO, April 3, 1931.

To the Ohio Academy of Science:

During the past year the Executive Committee has met four times—twice as an executive committee and twice in joint meeting with the vice-presidents, all members of the committee being present at all four meetings.

At the first executive committee meeting, held on November 15, 1930, in the office of the secretary, the time and place of the 1931 annual meeting were decided upon and definite plans inaugurated. The happy suggestion that this meeting be made a joint meeting of the Indiana, Kentucky and Ohio academies met with instant and unanimous favor and action was authorized accordingly. The results are before you.

Other items, perhaps of general interest, transacted at this meeting were:

1. That the Academy take two memberships at $12.00 each in the "Save Outdoor Ohio" Society, whereupon Mr. S. Prentiss Baldwin, of Cleveland, and Dr. E. Lucy Braun were elected to represent the Academy in this organization, with Dr. Herbert Osborn, Ohio State University, and Dr. A. E. Waller, same institution, as alternates. Mr. Baldwin later declined with regrets to serve, owing to lack of time and press of other work.

2. The Secretary was elected the official delegate on the Council of the A. A. A. S. and the Conference of State Academies.

3. The Publications Committee was requested to make report on the advisability and feasibility of re-publishing Lynds Jones' "Birds of Ohio."

The *second meeting* was held on February 7, 1931, in Parlor G, The Deshler-Wallick Hotel, Columbus, and was a joint meeting with the vice-presidents of the Academy. We also had with us, by invitation, Dr. N. E. Pearson, of Butler University, chairman of the Program Committee of the Indiana Academy, and Prof. Arthur T. Evans, Miami University, chairman of the Local Executive Committee at Oxford.

The main purpose of this joint meeting was, of course, a thorough survey and discussion of the many and various details involved in a tri-state gathering of the "wise men and women" of the three academies. After about two and one-half hours of earnest, frank discussion, practically all details were agreed upon and a provisional program prepared for the Preliminary Announcement of the annual meeting. The entire joint committee was pleased with the detailed set-up reported by Professor Evans for taking care of the meeting at Oxford.

The *third meeting* was also a joint meeting with the vice-presidents and was held last evening in Ogden Hall and was for the purpose of passing on nominations to Fellowship in the Academy. All members were present.

Following the adjournment of this joint meeting, the Executive Committee met in its fourth and final session of the year. The secretary laid before the committee the applications of some 57 persons for membership in the Academy and as they were in regular form and dues paid, it was unanimously voted to recommend their election to membership.

(See Note 1, under Important Miscellaneous Notes.)

Respectfully submitted,

WILLIAM H. ALEXANDER, *Secretary.*

Report of the Publications Committee.

OXFORD, OHIO, April 4, 1931.

To the Academy of Science:

The Annual Report of the Fortieth Meeting, Proceedings, Vol. VIII, Part 7, containing 107 pages, was published August 28, 1930.

With this was published the title page and table of contents of Vol. VIII of the Proceedings, consisting of the Annual Reports of the Thirty-sixth to Fortieth meetings, 1926–1930.

Respectfully submitted,

F. O. GROVER, *Chairman.*

Report of the Trustees of the Research Fund.

COLUMBUS, OHIO, March 31, 1931.

To the Ohio Academy of Science:

The following condensed statement of the Research Fund shows that we have made grants to the extent of $73.55, which, with interest additions during the year, leaves a free balance in the bank subject to check of $150.86.

SUMMARY OF ACCOUNT FOR 1930-31.

RECEIPTS.	
Balance in checking account, April 18, 1930	$ 166 91
Receipt from interest	57 50
Total	$ 224 41
EXPENDITURES.	
Grants to research projects	$ 73 55
Balance in checking account April 1, 1931	$ 150 86
SUMMARY OF ASSETS.	
Invested Funds—	
Bonds	$1,300.00
Bank certificates	300 00
Balance in checking account	150 86
Total resources	$1,750.86

It should be noted that our meeting is earlier in April than last year and interest payments due during the month will add to our cash balance. This will make possible further grants or an addition to the invested funds.

Respectfully submitted,

(Signed) HERBERT OSBORN,
L. B. WALTON,
Trustees.

Report of the Library Committee.

COLUMBUS, OHIO, April 2, 1931.

To the Ohio Academy of Science:

The past year has been a rather uneventful one as regards the work of the Library Committee. The Proceedings of the 40th meeting of the Ohio Academy of Science were received in September, 1930, and 704 copies were posted to the members of the Academy, to the exchanges, and to those institutions maintaining standing orders. There was left a surplus stock of 290 copies.

Four new exchanges were secured, making a total of 133. At the last meeting of the Ohio Academy of Science there was handed to the Chairman of this Committee a copy of a resolution adopted at the meeting of the various State Academies held in connection with the A. A. A. S. meetings at Des Moines in 1929. It proposed that each Academy send its publications to every other Academy in this country. As far as is known, twenty-four States and nine cities maintain Academies and one State has two. However, there may be more, for it was only last week that information was received concerning a new one, the Peoria Academy of Science. Negotiations are now being made concerning an exchange with it.

As regards the other Academies, the Ohio Academy of Science has arranged to exchange with all the State Academies and with all but one of the city Academies. No exchange has been offered, as its publication is purchased by our University Library. Some of the State Academies do not yet issue any publication, but assurance has been given that they will send them to us as soon as they do. These are not included in the number of exchanges as stated above.

Once each year and sometimes twice, a shipment of our publications is made ready to go to the exchanges in foreign countries. The first shipment for this year will be sent within the next few weeks.

The mailing list of the members of the Academy has been kept as carefully as possible. Sometimes the changes in addresses are not sent by the members and the information, if received at all, comes in various ways. It is always appreciated when official notification is received directly from the member making the change in residence.

The sales of publications have amounted to $89.40. This is the largest amount ever sold in any one year and is due to a recent order for a complete set of the Ohio Academy of Science Proceedings. It came from a library and will likely be followed by a standing order for each year's issues. An examination of the sales shows that 166 items were sold in 56 sales. These items consisted of 70 Annual Reports and 96 Special Papers. Three of the Academy members purchased Reports to complete their files of the Proceedings. It is hoped that more of our members will adopt this practice and thus secure complete sets for themselves and increase the sales for the Academy.

One or more copies of all the Special Papers were sold, showing that the demand for them comes from people interested in all the various fields represented by these Papers. At the meeting last year it was recommended that no more copies of Dr. Osburn's "Fishes of Ohio" be sold in separate sales, as the stock had become reduced to 25 copies. However, when the inventory was taken, an additional package containing 43 copies was found, making such recommendation unnecessary. Judging from the number of copies sold, Max Morse's "Batrachians and Reptiles of Ohio" was the paper most in demand. Next was the one on "Preglacial Drainage of Ohio," followed closely by Dr. Osburn's "Fishes of Ohio," Sterki's "Land and Freshwater Mollusca of Ohio," and Miss Detmer's "Ecological Study of Buckeye Lake." Then came Dr. Kellicott's "Odonata of Ohio," followed by Prof. Hine's "Tabanidæ of Ohio," Prof. Moseley's "Flora of the Oak Openings," Dr. Stover's "Agaricaceæ of Ohio," and Dr. Grigg's "Willows of Ohio." All the other Papers followed in fairly close succession. Eighteen of these 56 sales were made to people in Columbus, 17 to those in other cities in our own State, and 21 to persons residing in nine different States, Washington, D. C., and Ontario, Canada. The nine States extended from Massachusetts to California and from Minnesota to Tennessee.

The following financial report is submitted:

RECEIPTS.

Cash balance on hand April 18, 1930	$ 96 32
Collected on 1929–1930 sales	2 30
Sales for 1930–1931	89.40
Payment for Volume Ohio Journal of Science included in a check for Ohio Academy of Science publications	2 00
Bank dividends for 1930	3 12
Total receipts	$193.14

EXPENDITURES.

A. E. Waller, for sales, 1929–1930	$ 76 75
B. S. Meyer, for sale of volume Ohio Journal of Science	2.00
Total expenditures	$ 78.75

Cash balance on hand April 2, 1931	$ 83.49
Outstanding accounts	30 90
Expenditures, 1929–1930	78.75
Total	$193.14

SUMMARY OF ASSETS.

Sales for 1930–1931	$ 89.40
Accumulated bank dividends	24.99
Total balance	$114.39

Respectfully submitted,

ETHEL M. MILLER, *Chairman.*

Report of the Committee on State Parks and Conservation.

COLUMBUS, OHIO, March 31, 1931.

To the Ohio Academy of Science:

Your committee is pleased to be able to report considerable progress in activities for conservation and development of State Parks during the past year and also we hope that legislation now under consideration may give additional advantages in this line.

Your representatives on the "Save Outdoor Ohio" Council have co-operated in consideration of desired legislation and feel that this association is worth while and should be continued.

Among the items considered by the legislature is a bill to prevent depletion of clam beds in the streams of the state has been considered and recommended by the senate committee for passage and seems likely to be enacted into law. An anglers license bill has been under consideration and also is recommended for passage by the senate committee. A bill for taking quail from the song-bird list has been killed and a bill termed the "Live trap bill," for fur-bearing animals, has been postponed indefinitely and seems unlikely to pass.

Another bill which prohibits the holding of nets within one mile of the Ohio river is considered an additional protection to the fishes in the tributaries of the Ohio river. A further bill providing for the taking over of state lands for state parks has, in substitute form, been recommended for passage. A bill which is of special interest to some of our members, providing for the building of bridge dams in connection with highway bridges, has been passed by the senate and is being considered by the house, having had its first reading last week. There appears to be no opposition and the bill seems likely to pass. If passed it will make it possible to provide reservoirs or slack water in streams and should do much to preserve native conditions for aquatic life.

Another bill providing for the regulation of outdoor advertising along the highways has been especially sponsored by the Council and supported by many organizations and is likely to pass and is of special interest in protection of scenic localities from desecration.

The State forests, which are of particular interest as reserves for biological interests, have been considerably increased in area and we may conveniently quote from a recent statement by the State Forester:

"The past biennium saw a big increase in State Forests and Forest Parks in Ohio. During that period two State Forests, the Hocking Experimental Forest and the Zaleski Forest, and two Forest Parks, the Mohican Park and the Virginia Kendall Park, were added to the growing list.

"The most recent of these additions is the Zaleski Forest, situated in eastern Vinton County and having an area of 3,400 acres. It is the first area purchased in this County, although Waterloo Forest, in Athens County, is only four miles to the eastward and the two may in time be organized as a single unit.

"Acquisition of additional tracts adjoining or located near already existing Forests and Forest Parks has nearly doubled the total land holdings. The biggest increase has been made in Shawnee Forest. Two years ago this Forest covered an area of 17,000 acres, while now the area has increased to 35,800 acres. Pike Forest has increased from 3,550 to 7,588 acres. The other State Forests have not been increased so much.

The Forest Parks have not increased as greatly as the Forests have in the past two years. The Hocking Series has increased from 2,000 to 2,832 acres, the Virginia Kendall Park of 400 acres has been obtained, the Mohican Park of 350 acres purchased and increased later to 850 acres, and the Hocking Experimental Forest of 608 acres purchased, all in the past biennium.

"The total holdings of the Forestry Department on February 1, 1931, comprise 59,206 acres. This includes the Wooster Arboretum and the Marietta Forest Nursery."

There have been no notable additions to the area of game refuges, but a new State Park near Mt. Gilead, in Morrow County, is of interest as providing an attractive recreational park in a section of the state not otherwise supplied. If we recall the various holdings of the Archaeological and Historical Society, many of which are of biological and scenic interest, we can see that the state is gaining a considerable number of desirable tracts for forest conservation, wild life preservation, park and recreational purposes and that the movement is almost certain to gain momentum in the future. Taken altogether, we may feel encouraged in the outlook and continue the effort to convince the public of the value of these projects and the necessity for their proper administration.

Respectfully submitted,

HERBERT OSBORN, Chairman,
E. LUCY BRAUN,
J. E. CARMAN,
Committee.

Report of the Auditing Committee.

OXFORD, OHIO, April 4, 1931.

To the Ohio Academy of Science:

The Auditing Committee requests permission to report its audit of the Treasurer's report at a later date to the Executive Committee, in order to allow time to complete the records on some minor items.

The Committee has audited the accounts of the Board of Trustees of the Research Fund and finds them correct.

The Committee has audited the accounts of the Librarian of the Academy and finds them correct.

Respectfully submitted,

(Signed) EDWARD L. RICE,
J. E. HYDE,
Committee.

The report was accepted as read and the request of the Committee for further time in which to complete the audit of the Treasurer's books was granted.

Report of the Membership Committee.

OXFORD, OHIO, April 4, 1931.

To the Ohio Academy of Science:

Your committee recommends the election of the following persons to membership in the Academy whose applications in proper form are herewith and whose dues for one year have been paid:

ALDRICH, JOHN W., Cleveland.
ALTENBURG, JOHN D., Findlay.
ANDERSON, BERTIL G., Cleveland.
ATWOOD, HARRY, Columbus.
BACON, FRANKLIN J., Cleveland.
BAIRD, ROBT. L., Oberlin.
BEAN, L. G., Columbus.
BELLOWS, ROGER M., Columbus.
MILLER, EVERETT T., Columbus.
MUNN, LOTTIE E., Painesville.
NELSON, BELFORD B., Athens.
NETERER, INEZ, Painesville.
PATRICK, JAMES R., Athens.
PHEE, REV. MARTIN J., Cincinnati.
PIERSTORFF, A. L., Columbus.
RAUCH, R. P., Columbus.

Berlin, Leonore A., Painesville.
Bole, B. P., Jr., Cleveland.
Burrell, Charlene M., Alliance.
Cantrall, C. M., New Concord.
Conant, Roger, Toledo.
Cottrell, Casper L., Gambier.
Davis, B. M., Oxford.
Diller, O. D., Columbus.
Dodd, D. R., Columbus.
Elliott, Rush, Athens.
Foard, Castle W., Youngstown.
Frazier, Chas. H., Columbus.
Freeland, Ralph O,, Columbus.
Grimm, Wilbur W., Oxford.
Growdon, Clarence H., Columbus.
Hall, Clifton W., Columbus.
Herrick, Ervin M., Columbus.
Hyre, Russell A., Columbus.
Kalter, Louis B., Dayton.
Kirk, W. J., Steubenville.
Lehman, Harvey C., Athens.
Lockett, J. R., Columbus.
Ludwig, William B., Athens.
Lumley, Frederick H., Columbus.
MacLaurin, Dr. R. D., Cleveland.
Mathews, C. O., Delaware.
Mathewson, Stanley B., Springfield.
Reid, W. M., Circleville.
Riddell, Newton N., Lima.
Roach, Lee S., Athens.
Riecken, William E., Delaware.
Sawyer, Dr. Carl W., Marion.
Schaefer, Frances, Columbus.
Schoff, C. N., Oberlin.
Scott, Thurman C., Athens.
Shenker, Samuel, Columbus.
Sharp, Henry S., Granville.
Simonton, Owen D., Wooster.
Slavens, Margaret D., New Concord.
Smith, Prof. J. J., New Concord.
Stark, Orton K., Oxford.
Snyder, Lawrence H., Columbus.
Squires, G. R., South Euclid.
Stehr, William C., Athens.
Stetson, Harlan True, Delaware.
Stone, Robert G., Columbus.
Taylor, Dr. A. M., Painesville.
Uhrbrock, Richard S , Cincinnati.
Varvel, Carl Dudley, Columbus.
Weir, Kenneth J., Ashtabula.
Welch, Winona H., Greencastle, Ind.
Withrow, Robert B., Cincinnati.
Wood, C C., Akron.
Yowell, Everett I., Cincinnati.

Respectfully submitted,
Ralph V. Bangham, Chairman,
E. W. E. Schear,
W. H. Shideler,
Committee.

Report of the Committee on Election of Fellows.

Oxford, Ohio, April 4, 1931.

To the Ohio Academy of Science:

The Committee on the Election of Fellows has held but one meeting during the year, namely, on Thursday evening, April 2, 1931, at Ogden Hall, Miami University, Oxford, Ohio. All members were present. The following members whose nominations were in proper form and accompanied by satisfactory documentary evidence of the nominee's scientific achievements, received the required three-fourths vote of the committee and were declared elected to Fellowship, viz.:

E. Willard Berry
Helen Jean Brown
Arthur Thompson Evans.
Hope Hibbard
Carl E. Howe.
Lois Lampe.
H. C. Shetrone
Forrest G. Tucker.
Carl Ver Steeg
E. B. Williamson
Orville Turner Wilson.

Respectfully submitted,
William H. Alexander, *Secretary.*

(See Note 2 under Important Miscellaneous Notes.)

Report of the Committee on Necrology.

For lack of time the committee was unable to prepare a suitable written report, but the Chairman, Dr. Clarence H. Kennedy, made an oral report, speaking at some length on the life and work of Professor James S. Hine, of Ohio State University, and a former president of this Academy. A full written report will probably be received in time to appear in these Proceedings.—W. H. A.

Report of the Committee on Junior Scientific Effort.

OXFORD, OHIO, April 4, 1931.

To the Ohio Academy of Science:

I. INTRODUCTORY REMARKS.

Your committee appointed at the last session to investigate the Academy of Sciences and high school practice and procedure in the encouragement of Junior scientific endeavor has carried on considerable correspondence and held personal conferences with the officials of other academies and individuals. The committee desires to report some progress in the accumulation of information and offer several recommendations.

II. MATTERS OF INFORMATION.

1. A number of state Academies are investigating the same problem.
    a. The Iowa Academy has just begun the fact-finding process.
    b. The Indiana Academy has made some progress.
    c. The Illinois Academy began the work in 1926. Organized the first of the high school units of the Junior Academy of Science in 1929 and now lists 18 high school clubs as members of a Junior Academy. They have an annual meeting of the Junior Academy which, under the direction of Miss McEvoy, of Rockford High School, is making fine progress in working out of the project.
2. Thirty-seven Ohio high schools listed by the North Central Association of Colleges and Secondary Schools were sent questionnaires by your committee. The Principals of the high schools were asked:

    Does your High School have a Science, Biology, Physics or Geography club? Who is the teacher in the mentioned departments? What is the name of the club and who is responsible for its direction?

    Thirty replies were received from the thirty-seven letters with the following results:

Biology Club	4
Biology and Zoology Club	1
Botany Club	1
Chemistry Club	5
Physics Club	5

Science Club	7
No Club	6
Blank–does not answer–probably no club.	4

Also some high schools have two clubs.

The promptness and number of the replies indicates interest.

3. A number of high school principals and instructors in science have been interviewed concerning the project. If care is exercised in approaching the school administrators and the instructors, their sympathetic co-operation can be secured in the project. Furthermore, neither the school officials nor more particularly the students must be permitted to develop a feeling that something is being handed down to them. If it does occur, the project will fail. Care must be exercised in building committees and the project must not be rushed or hurried, if it is to succeed.

III. RECOMMENDATIONS.

1. That a chairman be appointed to continue the committee work. That a committee include in its membership Prof. E. S. Vinal, of Western Reserve University School of Education; Mr. B. F. Fulks, of Norwood High School, Cincinnati, Ohio, and Miss Muriel Aberly, of Mansfield, Ohio, High School, provided she accepts the invitation. Prof. Vinal and Mr. Fulks have already indicated a willingness to aid in the committee work. Furthermore, the committee should be composed of:
   a. From university and college:
      - A college administrator,
      - A college teacher of science who is particularly interested in teaching of science,
      - A college or university teacher who is capable of giving advice in the planning of research projects.

   b. From high school:
      - A high school principal or superintendent. (Mr. Fulks has accepted.)
      - A high school teacher in each of the following:
        Botany, Zoology or Biology; Physics, Geography.

2. That a maximum expenditure of $50.00 be voted this committee to carry on:
   a. Further investigation of the status and function of science clubs in the high schools. Paying the postage, mimeographing, etc., of such investigation.

   b. Preparing printed certificates of membership in a Junior Academy if it is found advisable.

   c. Keeping in touch with the work of other State Academies.

   d. Printing that may be necessary this year to interest the high school clubs.

Respectfully submitted,

C. G. SHATZER,
Chairman.

Report of the Special Committee on the Academy's Relation to the Ohio Journal of Science.

OXFORD, OHIO, April 4, 1931.

To the Ohio Academy of Science:

The committee recommends to the Ohio Academy of Science:

First. That it is desirable that the Ohio Journal of Science be published and controlled jointly by the Ohio Academy of Science and the Ohio State University.

Second. That the Ohio Academy of Science enter into such a relationship on the following conditions:

1. That the Ohio State University set up an agent that will be legally responsible for the University's interest in the Ohio Journal of Science.
2. That the Ohio State University, or its agent in the matter, agrees to the appointment of a joint Administrative Board for the Ohio Journal of Science. This Board shall consist of four members, two appointed by the Ohio Academy of Science from its membership outside the Ohio State University, and two by the Ohio State University or its agent.

   At time of establishment of this Board, one University member and one Academy member shall be appointed for two years, on nomination by the Nominating Committee of the Academy, and one each, for three years. Thereafter, appointments shall be for a term of three years and may be renewed on expiration.

   The Administration Board shall determine the editorial and business policies of the Ohio Journal of Science. It shall appoint the Editor, Business Manager, and such Editorial Staff as seems desirable. The Editor-in-Chief and Business Manager of the Ohio Journal of Science shall participate as non-voting members in the deliberations of the Administrative Board, except that in the event of a tie vote, the Editor-in-Chief may cast the deciding vote in all matters except that having to do with appointments to the positions of Editor-in-Chief and Business Manager. In the event of absence of one representative of either party to this agreement, proxy is given by this agreement to his colleague to vote for the absent member on all matters coming before the Committee.

   The Committee shall elect its Chairman and Secretary, shall keep records of its actions and transmit a report to the Academy at the annual meeting and to the agent for the Ohio State University. This report shall record important decisions and shall include the financial statement of the Ohio Journal of Science for the immediately preceding fiscal year of the Journal of Science.
3. That it will be mutually agreed by the Ohio Academy of Science and the Ohio State University, that this plan may be terminated on a year's notice by either party.

It further recommends:

That the present special committee on the Academy's Relation to the Ohio Journal of Science, jointly with the Publications Committee of the Academy, be charged with the negotiations with the Ohio State University looking to the adoption of the plan by the University.

That the President of the Academy fill the vacancies in the Special Committee on Publication Relations.

That the Secretary of the Academy place on file as a part of his records, the report on Publication Relations of the Ohio Academy of Science which was prepared by the Committee as a basis for its recommendations.

Submitted and signed by

EDWARD L. RICE, Chairman,
J. E. HYDE,
Committee.

Report of the Nominating Committee.

OXFORD, OHIO, April 4, 1931.

To the Ohio Academy of Science:

Your committee on nominations, elected a year ago, respectfully submits the following report:

President—ALPHEUS W. SMITH.

Vice-Presidents:

A. *Zoology*—J. PAUL VISSCHER.
B. *Botany*—ARTHUR T. EVANS.
C. *Geology*—EDMUND M. SPIEKER.
D. *Medical Science*—SHIRO TASHIRO.
E. *Psychology*—HORACE B. ENGLISH.
F. *Physical Sciences*—FORREST G. TUCKER.

Secretary—WILLIAM H. ALEXANDER.

Treasurer—A. E. WALLER.

Executive Committee—(Elective Members): A. F. FOERSTE and C. G SHATZER.

Trustee, Research Fund—GEORGE D. HUBBARD.

Publications Committee—F. O. GROVER, F. C. BLAKE, E. L. MOSELEY.

Library Committee—L. B. WALTON.

Committee on State Parks and Conservation—HERBERT OSBORN, EDWARD S. THOMAS, W. E. STOUT.

Respectfully submitted,

EDWARD L. RICE, Chairman,
L. H. TIFFANY,
J. E. CARMAN,
R. J. SEYMOUR,
E. H. JOHNSON,
Committee.

At the conclusion of the reading of the report, the President called for nominations from the floor. There being none, a motion was made and duly seconded that the report be approved as read and that the persons named be the officer of the Academy for 1931–1932. Carried unanimously.

Report of the Committee on Resolutions.

OXFORD, OHIO, April 4, 1931.

To the Ohio Academy of Science:

The Committee on Resolutions beg leave to make the following report:

The Ohio Academy of Science expresses its very real appreciation of the courtesies extended by the various authorities and committees of Miami University for our unusually successful meeting and especially for the home-like atmosphere with which they have so happily surrounded us.

We wish further to express our appreciation for the stimulation brought to these meetings by the co-operating societies.

And we recommend that the secretary properly express this sentiment to those concerned and to inscribe these records as part of the minutes of this meeting.

Respectfully submitted,

PAUL S. VISSCHER, Chairman,
E. LUCY BRAUN,
E. H. JOHNSON,
Committee.

THE SCIENTIFIC SESSIONS.

GENERAL AND SECTIONAL.

The following is a complete list of the addresses and papers presented at the various general and sectional meetings of the Academy.

(Numbers in parentheses after the title refer to abstracts.)

1. Traces of early man in western Europe.................. F. O. GROVER
2. Ancient life of the Arctic (Presidential Address).......... A. F. FOERSTE
3. Points of historical and scientific interest in Indiana .... J. J. DAVIS
4. An optimistic view of the evolution of sciences..............V. F. PAYNE
5. Moving partition walls (Welcome Address) ... ... PRESIDENT UPHAM
6. Micro-moving pictures of the circulation in living bird embryos, (1) BRADLEY M. PATTEN and T. C. KRAMER
7. Laboratory study of living birds (2)...................S. PRENTISS BALDWIN
8. Regulation of body temperature in birds (3)...........S. CHARLES KENDEIGH
9. Nesting success in a song sparrow population in 1930 (4) MARGARET M. NICE
10. The heronries of northern Ohio (17)......................E. L. MOSELEY
11. The dietary habits of barn owls in Ohio (6)............ARTHUR STUPKA
12. Some factors which limit or determine the distribution of some economic insects in the United States ....DWIGHT M. DELONG
13. Parasites of Buckeye Lake fish (7)................. RALPH V. BANGHAM
14. A gilled oligochaete new to America: *Branchiura sowerbyi* in Buckeye Lake (8)..................................WARREN P. SPENCER
15. *Tanais cavolinii* Milne-Edwards (Crustacea) (9)............S. R. WILLIAMS
16. The development of the thoracic pleurites in the embryo of Conocephalus and its bearing on the ancestry of the insects and their allies..L. B. WALTON
17. The respiratory apparatus of *Parajulus impressus* Say (10).....R. A. HEFNER
18. Factors controlling the distribution of Cladocera in northern Ohio, J. PAUL VISSCHER
19. The recovery of a stream after pollution..................C. A. BARKER
20. Notes on the ecology of some grasshoppers of the genus Melanoplus (11), EDWARD S. THOMAS
21. The interpretation of the influence of environmental factors...L. L. HUBER
22. Some observations on the behavior of *Passalus cornutus* (Coleoptera) (12), WARREN C. MILLER
23. A limnological study of the Hocking River. (a) The plankton of the Hocking (13)..................................LEE STEWART ROACH
24. A limnological study of the Hocking River. (b) The bottom invertebrates of the Hocking (14).........................WILLIAM B. LUDWIG
25. The embryology of the whitefish *Coregonus clupeaformis* (Mitchill) (15), JOHN W. PRICE
26. Histology of the intestinal tract of two minnows, *Notemigonus chrysoleucas* (Mitchill) and *Notropis atherinoides* (Rafinesque) (16), THOMAS SURRARRER
27. The morphology of the anterior autonomic nervous system of the earthworm (Lumbricus) (5)..................C. C. ROGERS and T. T. CHEN
28. On the habits of Ohio reptiles in captivity................ROGER CONANT
29. Skinning our parks (16a)...........................S. PRENTISS BALDWIN
30. The differentiation of shoddy in woolens by statistical methods, L. B. WALTON

31. Preliminary report on the phototropic responses of *Drosophila hydei*. (Read by title) (10a). . Walter S. Wilde, (Introduced by R. A. Hefner)
32. Is previous experience with plants related to the efficiency of freshman students in botany? . . . O. T. Wilson
33. The Lemnaceae of Ohio . . . . Lawrence E. Hicks
34. Some poisonous plants indigenous to Indiana (18). . . . George W. Finley
35. A key to the commoner Ohio Hydnums. . . . . W. G. Stover
36. Some freshwater Algae of Southern Florida (19) . . . L. H. Tiffany
37. Cleistogamy in Amphicarpon . . . . Paul Weatherwax
38. Propagation of Equisetum from sterile aerial shoots . . John H. Schaffner
39. Pollen analysis of Bacon Swamp, Indianapolis; evidences of two dry climatic periods in the post-Wisconsin (20), Paul B. Sears and A. E. Waller
40. Barberry seed germination and seedling survival under natural conditions in Ohio. . . . W. G. Stover and C. W. Horton
41. Distribution of escaped common barberry in Ohio, C. W. Horton and W. G. Stover
42. The correlation between dry weather and the storage of organic reserves in alfalfa roots (21). . . . C. J. Willard
43. Concerning certain concepts of plant sociology. . . Stanley A. Cain
44. Life forms of plant communities of the Cincinnati region, Alice Phillips
45. Precipitation, periodicity and natural vegetation . . . E. N. Transeau
46. Growth irregularities in hybrid Freesias induced by X-Rays W. P. Morgan
47. The physiological basis of cold resistance in evergreens . Bernard S. Meyer
48. Absorption of water by root systems of plants (22). . Paul J. Kramer
49. New dyed cellophane filters for the investigation of the effects upon plants of the ultra-violet radiation at the limits of the sun's spectrum, Robert B. Withrow
50. The loss in dry matter in sweet clover roots from fall to spring (23), C. J. Willard
51. The Gratz division of the Cynthiana series of Central Kentucky (24), J. J. Wolford
52. The Devonian corals of Ohio (25) . . . . Grace A. Stewart
53. A further report on the section at Hamburg, Ind . . W. H. Shideler
54. The horizon of the Brassfield limestone in southeastern Ohio (26), James W. Cummins
55. Origin of limestone caverns (27). . . . . A. C. Swinnerton
56. Recent formation of dolomite in an Ohio Cave (28). . . Richard C. Lord
57. Some temperature abnormalities in Indiana and Kentucky highs (29), Robert Kendall and Ernest Rice Smith
58. The Finns in Ohio (30). . . . . Eugene Van Cleef
59. Erosion surfaces in eastern Ohio (31). . . . . Karl Ver Steeg
60. Some features of the surficial deposits of Licking County, Ohio, G. W. Conrey and A. H. Paschall
61. Paragenetic relations of galena and sphalerite (32) . . . . Ralph Tuck
62. Brines of the deep-seated rocks . . . . Wilber Stout
63. The subsurface in eastern Kentucky . . . . Lucien Beckner
64. Announcement of plans for the annual spring field trip (33). . Frank J. Wright
65. A remarkable fossiliferous lens in the Bainbridge limestone of Missouri (34), Paul H. Dunn

65a. The Foraminifera of the Bainbridge (35) . . . . Paul H. Dunn

66. Pre-Mesozoic stratigraphy of the central Wasatch mountains (36), A. A. L. Mathews

67. The earliest known Cephalopods of America, Europe and Asia, (37) AUG. F. FOERSTE
68. The status of paleobotany in Ohio (38)... ... .WILLARD BERRY
69. The footprints from the Pennsylvanian (39).........ROBERT H. MITCHELL
70. Structural geology of northern and central Kentucky.. .. W. R. JILLSON
71. Is orogenic deformation continuous or discontinuous for the earth as a whole? (40)........ .... WALTER H. BUCHER
72. A comparison of the Maine and Connecticut shorelines (41).HENRY S. SHARP
73. Industrial adjustments in the Miami valley (42) .... A. J. WRIGHT
74. Summer rainfall of 1930: A relative representation (43). . .R. B. FROST
75. Geology of the vicinity of Ticonderoga, N. Y. (44). .. .A. C. SWINNERTON
76. The hypsometric map versus the projected profile method in portraying and determining erosion levels. (To be read by title)(45) .KARL VER STEEG
77. Late Paleozoic and early Mesozoic Pugnoides. (To be read by title), A. A. L. MATHEWS
78. Some variations in muscular efficiency (46) .... WALTER C. MCNELLY
79. Oxygen pulse under hypnosis (47)............ .. .. B. M. DAVIS
80. Health habits of university women (48)...... .. ....MRS. NORMA SELBERT
81. Studies on the basal metabolism of college students (49), C. G. ROGERS and R. L. KROC
82. Silicosis in Ohio industries (50).......... .... B. E. NEISWANDER
83. The status of dental hygiene (51) .... .LONZO G. BEAN
84. The blood pressure of the opossum (52).... .... HOWARD E. HAMLIN
85. Further studies on experimental gastric ulcer (53), SHIRO TASHIRO and L. H. SCHMIDT
86. Physical treatment of behavior difficulties .... EDNA R. LOTZ
87. Anti-anemic influence of dessicated hog stomach ... . A. B. BROWER
88. Science versus crime . ... HERBERT S. MIKESELL
89. Adequate emotional stimuli and the psychogalvanic experiment, B. B. NELSON and JAMES P. PORTER
90. The effect of cinchophen on the liver of white rats, L. B. NICE, R. M. KNOBLE and H. A. SMITH
91. Sex-character education through pets. (An experiment with children at the Nature Guide School, Western Reserve University) (54), WILLIAM G. VINAL
92. Orientation of white rat on elevated maze ... . .EDWARD NEWBURY
93. The effect of emotional stimuli on the activity of the white rat, JAMES R. PATRICK
94. Some recent findings in the part and whole methods of learning, C. C. WOOD
95. A comparison of the high relief finger maze and improved form of the stylus maze.......... .... .T. C. SCOTT
96. Influence of grouping on serial learning of multiple choice ..F. H. LUMLEY
97. Experimental evaluation lecture: Quiz versus recitation method in teaching elementary Psychology... . ...H. H. REMMERS
98. An objective study of student and faculty attitudes toward academic honesty...G. O. MATHEWS
99. Some attitudes related to intelligence.............GORDON HENDRICKSON
100. A diagnostic technique for studying social and emotional adjustment (55), O. A. OHMANN
101. The selection of indices of "Progress" of Ohio Counties......G. W. HALL
102. The mental status of reformatory women................C. H. GROWDON
103. How scientists differ in reporting their church affiliations in "Who's Who"..H. C. LEHMAN

104. Rating scales in industry............R. S. Uhrbrock
105. The effect of hypnosis on long delayed recall............J. M. Stalnaker
106. The effect of rhythm and reverie on the machine worker, Stanley B. Mathiewson
107. Visualizing molecular encounters by means of models............H. P. Knauss
108. The lecture-demonstration and individual laboratory methods of *introducing college students to first year chemistry,* C. C. Ross and V. F. Payne
109. Some ideas about sound that are not sound............Arthur L. Foley
110. Note on the change of the upper frequency limit of audition with increasing age............L. W. Taylor
111. Equilibrium conditions in stars............H. M. Roth
112. The present-day picture of cosmic change............L. H. Thomas
113. A photometric study of the appearance of the spectral lines in a condensed discharge............H. V. Knorr
114. Wave-length measurements in the Schumann region, D. S. Marston and R. V. Zumstein
115. The absolute measurement of X-rays of long wave-length by reflection from a ruled grating............Carl E. Howe
116. Efficiency of characteristic X-rays............D. Berkey
117. Comments on the nature of X-ray absorption and scattering. S. J. Allen
118. Cold emission from unconditioned surfaces............Willard H. Bennett
119. Effect of low speed electrons on bacteria............D. A. Wells
120. A study of some electrical phenomena by means of the cathode ray oscillograph............Richard H. Howe
121. Potential gradient and space charge in atmospheric electricity, C. H. Dwight
122. Some fundamental experiments on side-bands............R. R. Ramsey
123. Television, yesterday, today, and tomorrow............R. B. Abbott
124. Organization of Physics and Physicists in Ohio. Remarks by the Retiring President............C. W. Jarvis
125. Vibrations in a wire carrying an electric current............R. Schaffert
126. *A null electrical method for the measurement of magnetic field intensities,* R. L. Edwards and W. C. Dod
127. Magnetic susceptibilities of binary alloys............F. L. Meara
128. Galvanomagnetic and thermomagnetic effects in permalloy and Perminvar............A. R. Fouts
129. A lecture-demonstration of the Bernoulli principle............S. J. M. Allen
130. A determination of the déelectric constants and deusilies of bromo-benzene—nexane solutions and the determination of the electric movment of the bromo-benzene molecule (56)............Louis M. Heil

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DEMONSTRATIONS AND EXHIBITS.

1. The technique used in determining human blood groups............L. H. Snyder
2. The common barberry with charts and specimens, Wayne F. Leer and Harry Atwood
3. New Psychogalvanic Apparatus............B. B. Nelson and James P. Porter
4. The distribution of Alleghenian species of amphibians in Ohio, Charles F. Walker
5. Charts and photographs illustrating the dietary habits of barn owls in Ohio............Arthur Stupka
6. Persistent first premolar teeth in the horse, James E. Miller. (Introduced by R. A. Hefner)
7. A plankton bottle............Lee Stewart Roach
8. Drawings of Ohio Ants............Clarence H. Kennedy
9. Orthoptera not hitherto reported from Ohio............Edward S. Thomas
10. Ohio species of Melanoplus............Edward S. Thomas
11. American species in horticulture............H. H. M. Bowman

PRESIDENTIAL ADDRESS

ANCIENT LIFE OF THE ARCTIC

AUG. F. FOERSTE.

Former ideas of the origin of the earth and of the life upon it were conditioned by our belief in the Laplace theory. According to this theory, the earth, as well as the remainder of the solar system, originally was part of an enormous rotating mass of gas, which later cooled to a liquid state, and finally, in the case of the earth, was covered by a solid crust. The atmosphere surrounding the earth, according to this theory, originally was very hot, and only gradually cooled to the much lower temperatures known under modern conditions. Life was supposed to have begun, while the atmosphere still was hot, or at least very warm. Former climates were supposed to have been not only warm, but nearly uniform around the entire earth; in other words, about as warm in polar areas as at the equator. To account for such an anomalous distribution of climates, the atmosphere of those ancient times was supposed to have received its heat chiefly from the interior of the earth, and not from a source exterior to the earth, namely, the sun. The rapid loss of the heat of the earth's atmosphere by radiation was supposed to have been prevented in large part by an abundance of heat absorbing gases, chiefly moisture and carbon dioxide, in this atmosphere. The control of the climate of the earth by an outside agency, the sun, rather than by an inside source, the heat of the interior of the earth, was supposed to have originated relatively recently, geologically speaking, some placing the time at which this change of control took place even as late as the Upper Tertiary. From this point of view, therefore, former climates, with their uniformly warm conditions over the entire surface of the earth, and their absence of climatic zones, differed greatly from the strongly contrasting climates existing at present.

According to the Laplace theory, therefore, the oldest rocks on the surface of the earth were formed under conditions of great heat. This opinion, for many years, appeared confirmed by the fact that, all over the surface of the earth, the oldest or Archaean rocks are crystalline, consisting of granites, gneisses and schists, supposed to have been produced under the influence of great heat. Recently, however, it has been discovered that in Finland these schists of Archaean age show evidences of cross-bedding, and that at various horizons they even contain distinct layers of conglomerate. Add to this the fact that at various localities these schists are interbeded with quartzite and various kinds of calcareous rocks, and the evidence becomes clear that Archaean rocks were deposited not under the influence of great heat, but under that of running water. Further study has shown, moreover, that the granites of the Archaean are not older than the schists, but younger, being intrusive into the latter. In other words, the schists originally were of sedimentary origin, but later became crystalline, under the influence of regional metamorphism induced by enormous masses of intruding granite.

However, unquestionably the greatest blow to our former belief in the igneous origin of Archaean rocks was that administered by the more recent discovery that, in the Huronian, conditions in certain northern areas were distinctly glacial; in other words, the exact opposite of igneous. During the Huronian, for instance, glacial tillites or clays extended from northern Wisconsin across southern Canada to the area southeast of the southern extension of Hudson Bay, a total east and west extension of 800 miles. At Cobalt, 330 miles directly north of Toronto, this tillite contains glacially striated boulders. Near Opazatica lake, 50 miles north of Cobalt, the glacial tillite rests on flat surfaces of older rock marked by Glacial scratches running N. 60° E. Glacial scratches occur also on the surface of the rocks beneath the Huronian glacial tillites at Matachewan, 100 miles northwest of Cobalt. Similar conditions, namely glacial tillites containing scratched boulders and resting on smoothed rock surfaces also showing glacial scratches, are known also at Varangerfjord, immediately east of the extreme northern end of Norway, in strata formerly regarded as of Lower Cambrian age, but at present regarded as possibly Pre-cambrian. Glacial conditions are cited also from the Pre-cambrian in Spitzbergen, about 600 miles north of Norway, and at the mouth of the Lena river, in Siberia. These areas are sufficiently circumpolar in their distribution to suggest cold, rather than hot climates, throughout the entire polar region at the northern end of the earth.

Following Pre-cambrian times, no wide-spread glacial conditions are known until near the close of the Paleozoic epoch, during the so-called Permo-carboniferous. During this period glacial tillite, containing striated pebbles, was wide-spread in India, in both eastern and western Australia, and near the southern end of Africa. This again is a circumpolar distribution, but around the southern pole of the earth.

The last wide spread glaciation of the world again is a northern one, that of Pleistocene age, familiar to all of us, and well exhibited in our own area.

Evidently, life did not begin under the influence of hot, or at least very warm atmospheres, gradually ameliorating to those contrasts of climatic zoning which now surround us.

The question arises, how did the belief originate that certain polar areas formerly existed under tropical conditions? The basis for this belief certainly was meager and not reliable. Along the middle of the west coast of Greenland there are about 20 exposures of Eocene strata from which 282 so-called species of plants have been identified, chiefly based on leaves of trees, but including also numerous flowers and fruits. Among these leaves there are two species of monocotyledonous plants which resembled those of palms, and which were described as species of Flabellaria. However, more exact study of these leaves have by no means served to definitely confirm their identification as palms. On the contrary, all of the numerous associated species of tree and shrub life, such as the willows, poplars, birches, and hazels, indicate cool temperate climates, and not tropical conditions. Absence of tropical conditions is indicated also by the presence of leaves of alders, beech, oaks, elms, sassafras, sycamore, ash, dogwood, tulip tree, maple, and sweet gum, which possibly indicate a warmer climate than that suggested by the trees cited first, but certainly nothing warmer than warm temperate, and under no circumstances anything as warm as tropical, or even subtropical. This prevalence of leaves of willows, poplars, birches, and hazels is not confined to the Eocene of west Greenland, but occurs also in the Eocene of Iceland, Spitzbergen, Novaya Zemblya, Siberia, and S. E. Alaska. In other words, during the Eocene, this cool temperate tree flora was circumpolar in distribution.

Similar evidence, at first sight also of conflicting character, is presented by the tree flora of the middle part of western

Greenland during the Upper Cretaceous. In these strata there occurs a specimen of Artocarpus, the genus to which the tropical bread-fruit tree of modern times belongs. However, the abundant associated flora is preponderatingly of a temperate climate character. Berry, the paleobotanist, very pertinently asks whether more weight should be given to a single species suggesting tropical conditions, or to numerous species all indicating temperate climates? Evidently the answer desired is that in favor of the preponderating evidence, the one in favor of a temperate climate.

Prior to the Middle Cretaceous the plant life of the earth was so different in character from that existing at the present time that it is difficult to arrive at any definite conclusions regarding the climatic conditions existing then. However, the presence of seasonal growth rings in the fossil woods of Lower Cretaceous and of earlier age suggests that there were at least changes corresponding to our alternations of summer and winter. Moreover, such seasonal rings are characteristic rather of trees growing in temperate zones than of those living in the tropics. For instance, one tree trunk, found in the Lower Cretaceous of King Charles' Island, east of the Spitzbergen group of islands, was found to retain 210 seasonal growth rings, although the outer part of this trunk evidently was not preserved. At a still earlier age, in the Jurassic of Spitzbergen, 9 kinds of coniferous woods were found which showed pronounced seasonal growth rings. During the Culm or Lower Carboniferous, corresponding in age to our American Mississippian, distinct seasonal growth rings were found in the gymnospermous tree trunks belonging to the genus Dadoxylon in Russia, in the province of Silesia in southeastern Prussia, and in the Vosges area of northeastern France. Although Dadoxylon occurs as early as the Devonian, seasonal growth rings appear unknown from strata of this age. This, however, must not be interpreted as indicating the absence of seasonal changes. Even during the Culm all species of Dadoxylon did not show growth rings.

Two things impress the student of ancient Artic tree floras. First, that, during Eocone and Cretaceous times, floras now characteristic of temperate climates at that time extended much farther north, occurring, in fact, in Greenland, Spitzbergen, and other Arctic lands, as already stated. Second, that temperate climate floras had a much greater north and south geographical range. In other words, that climatic zoning was far less accentuated then than at present. Nevertheless, we are not without indications of climatic zoning even in the geologic past. For instance, Heer concluded from his study of the Eocene flora of Greenland that the climate of that area was distinctly cooler than that of the supposedly contemporaneous flora found in the Eocene of Switzerland. Moreover, according to Berry, the Jackson or Upper Eocene flora of the southern United States finds its nearest living relatives along the present Gulf coast, and therefore suggests a climate not only warmer than that of Greenland, but also that of Switzerland. Similar differences of climate are noted also along the Pacific coast of North America, where, according to Hollick, the Eocene flora of northern Alaska was distinctly cooler than the contemporaneous flora of S. E. Alaska, the latter containing cycads and palms. In fact, the climate of southeastern Alaska appears to have been considerably warmer than that at corresponding latitudes along the Atlantic coast. Seasonal climatic zones appear to have been present at least as early as the Lower Cretaceous, at which time, according to Gothan, the coniferous woods of King Charles land, east of Spitzbergen, showed more pronounced growth rings than those of the same age in central Europe. From this it may be assumed that climatic zoning was present at least as early as the Eocene, probably as early as the Lower Cretaceous, and possibly as early as the Culm or Lower Carboniferous, if the presence of seasonal growth rings in the trunks of trees can be regarded as indicative of temperate, rather tropical climatic conditions.

The distribution of life in the existing seas is exactly opposite to that on the land. The cold waters of the Arctic may contain a relatively smaller number of species, but these Arctic species are represented by a vastly greater number of individuals of each species, than is usual in tropical and subtropical areas. Johnstone, in his Study of the Ocean (1926, p. 138) states that in the sea animal life of all kinds, both in surface waters and on the sea bottom, is more dense in polar areas than it is in intertropical ones. Jenkins, in his Text-book of Oceanography (1921, p. 98) states that, generally speaking, the open oceans are less rich in plankton (floating sea life) than coastal waters; and, again, that tropical seas are poorer in animal life than colder waters, and that this difference is dependent directly on the much greater amount of plant food found in Arctic waters.

All students of Arctic marine life have been struck by the great abundance of miscroscopic marine algæ, chiefly diatoms and the like. This remarkable abundance is favored by the cold temperature of Arctic marine waters. At cold temperatures, as is well known, water can absorb and retain a much larger volume of any gas. For the development of plant life this means carbon dioxide. It has also been stated that the denitrifying bacteria are far less common in cold waters than in warmer waters, thus insuring a more abundant supply of nitrogen for plant growth in Arctic seas.

Upon this abundant microscopic plant life feed the myriads and myriads of minute crustaceans and other minute marine animals, which in turn serve as food for successively larger animals until the giants of Arctic waters are reached, such as the whales, walrus, sea lion, the seals, numerous fish, and the less familiar invertebrate animals, including even the giant squid. In this connection we must not forget the extremely abundant bird life of the Arctic, almost entirely dependent for its food on the sea; in the last analysis, on the abundance of marine plant life.

Unfortunately, marine life, though far more abundantly represented in fossil form than terrestial plants, has so far not proved a dependable indicator of former climatic conditions. This has been emphasized recently by Kirk, in his paper on Fossil marine faunas as indicators of climatic conditions. (Smithsonian Rept., 1928, pp. 299–307). This does not mean that no attempts have been made to deduce the character of former climates from fossil marine evidence.

It has long been a dogma that organisms secreting much lime can not thrive in cold waters. From this it has been assumed that the presence of corals in the Upper Ordovician of northern Greenland, and eastern Ellesmereland indicates the existence at that time of warm water climates. However, much more must be known than the mere presence of corals before such a conclusion can be drawn. Even at present certain types of coral exist much farther northward and at much lower temperatures than ordinarily suspected. As long ago as 1914, Pratje reported the presence of 4 species of corals along the western coast of Norway, as far as its northern edge. These corals range along the entire width of the continental shelf bordering on that coast, down to depths as low as 350 to 1000 feet below sea level, and at temperatures as low as 44° F, which is only 12 degrees above the temperature at which ordinary water freezes. These species belong to two genera of Oculinidæ, namely Lophohelia and Amphihelia, and one genus of the Eupsamidæ, namely Dendrophyllia. (Centralblatt fur Min. Geol. Pal., 1914, 410–415). Moreover, even at present, it is the reef-building corals, rather than corals in general, which are confined to warm waters. Now, no one who has ever studied the corals of Ordovician or Silurian strata, or for that matter from any other Paleozoic horizons in the Arctic can state that any of these ever formed reefs. Moreover, none of these Arctic corals from Paleozoic strata are even remotely related to modern reef-building corals. Hence any conclusions drawn from their former presence can have no value beyond that of a wild guess.

Again, the calcareous shells of marine mollusks are said not to attain as great a thickness in cold waters as under warmer conditions, but I do not know how well established this observation is. It also has been asserted that in cold waters mollusks do not grow as vigorously and therefore attain a smaller size. But it is probable that any other unfavorable condition also might result in a smaller size. At all events, no difference either in size or in the thickness of the shell has been noticed in the relatively numerous species of brachiopods, gasteropods, and cephalopods found in the Red River formation, of Upper Ordovician age. This formation has the greatest north and south range of any Ordovician formation known. It extends from northern Greenland and the adjacent part of Ellesmereland southward across Hudson Bay and Manitoba, to Montana, Wyoming, and Colorado, a total distance of more than 2000 miles, in a north and south direction, and yet, shows remarkably little difference in the character of its fauna.

In general, marine faunas are controlled in their distribution chiefly by the routes of travel open to them. Under certain conditions, ocean currents may favor their migration to areas far distant from their points of origin. This does not mean that ocean currents carry these faunas along mechanically. However, these currents may take with them those conditions of warmth, or cold, or salinity which these faunas, and the food on which they depend, find congenial, and which at the same time favor their powers of reproduction. All are familiar with the ameliorating effects of the warm waters of the Gulf Stream on the climate of western Great Britain and Scandinavia. An opposite effect is achieved along the western coast of South America by a northward flowing current of the Pacific, which permits the seals and penguins of the Antarctic to reach the shores of tropical Peru.

At present, the Arctic is almost a land-locked sea No conspicuous currents are charted as passing through Bering Strait. Moreover, the ameliorating effects of the north arm of the Gulf Stream on the temperature of Arctic waters does not extend north of Spitzbergen or Franz Joseph Land, nor east of Novaya Zemblya. In general, therefore, the present Arctic does not receive any appreciable quantity of warm water from the more southern seas. Hence, it is distinctly colder than the North Pacific and the North Atlantic. In fact, the Arctic, at present, is abnormally cold, much colder than it was during Eocene, Cretaceous, and Jurassic times. For the following reason. During the Middle Eocene there was free communication between the Arctic and equatorial waters across wide areas of western North America and Siberia which at present are above sea level. During this time the warm waters of more southern areas had free access to the open Arctic sea, and produced a corresponding amelioration of its temperature. Berry, the paleobotanist, was the first to explain the far northward extension of tree floras now known only in cool temperate climates, to areas as far north Greenland and other polar areas, during late Eocene times, by calling attention to this wide-spread submergence of continental areas during the preceding Middle Eocene, with its resulting free oceanic connections, pointing out the fact that these Eocene floras occurred along the coasts of Arctic lands, where they would be under the influence of climates affected by warm ocean currents.

Possibly the northward migration of the Canadian or Beekmantown faunas of Newfoundland and the St. Lawrence basin to northwestern Scotland and to Bear Island, between Norway and Spitzbergen, was assisted by the warm waters of some northward flowing current, similar to the present Gulf Stream, carrying the peculiar genus Piloceras to these outlying areas. In a similar manner, the American genus Gonioceras makes its appearance in the Black River strata of Bear Island, and the American genera Billingsites and Apsidoceras, during Richmond times, may have migrated from Anticosti and the Gaspe region northeastward to southern Norway, Sweden, and Esthonia, the latter forming the southern margin of the Finland arm of the Baltic.

At present, the dominating currents of the northern oceans have a clockwise course, flowing northward along the western part of their circuit, and southward along their eastern part. In the southern hemisphere this direction is reversed, the major currents here having a counter-clockwise course. Such currents often produce very dissimilar distributions of marine faunas on opposite sides of the same continent. For instance, Ernst Stromer has pointed out that in the case of Africa, both at present and during Pleistocene times, coral reefs extended far south along the east coast but were almost entirely absent on its west coast. Again, during Eocene times, the nummulitic foraminifera extended along the eastern coast of Africa as far south as the southern end of Madagascar, while, along its western coast, they reached only the southern border of Nigeria, which is 2000 miles farther north. This suggests that Africa was an independent continental mass, widely separated from South America and also from eastern lands, at least as early as the Eocene.

We have become familiar in recent years with the theory of continental drift, proposed by Wegener. This theory calls attention to the similarity of the western outline of Europe and Africa, and the eastern outline of North and South America. It also imagines that the two sets of continents, now widely separated, formerly were in contact with each other. Gradually the American continents drifted westward, separating from Europe and Africa, and the intervening Atlantic Ocean originated. This is a bold and inviting theory. A more detailed study of its implications, however, will reveal many difficulties. In the first place, the two sets of continental outlines do not match as well as, at first thought, supposed. In the second place, it ignores altogether the physical improbability of such a shift, no adequate force being known. In the third place, it does not give enough attention to the difference of tectonic structure of the continents east of the Atlantic, compared with those on its west. And, in the fourth place, it does not account for the great differences in the faunal life of the two sets of continents, when compared with each other.

Indeed, as far back as the Permo-triassic, according to Diener, the vertebrate life of South Africa and that of South America already was too different to admit of any contact at that time between these two continents. And it should be remembered that according to the Wegenerian theory at this time Africa and South America were supposed to have been still in direct contact.

You all are familiar, of course, with an earlier theory which attempted to account for the similarities of life found, at various periods of geological history, in southern Africa and in the southern part of South America. This is the theory of a former land connection which bridged that part of the Atlantic which was between the southern part of these two continents. This theoretical land was called Atlantis. This also was an inviting theory. However, as our knowledge of the distribution of life in past geological ages grew the evidence accumulated that the ancestors of the animals, now in common to the southern parts of Africa and of South America, once were widely spread over more northern lands, where they probably had their common origin. At least, such a long and thorough student of Tertiary vertebrate faunas as W. D. Matthew was strongly opposed to any theory involving any form of land connection between these two continents, insisting that our knowledge of the evolution of these vertebrates led to a directly opposite conclusion, namely the entirely separate development of these two sets of faunas, subsequent to their northern origin.

Almost all marine life found in fossil form on the surface of the earth originated in the shallow seas. Deep sea fossil faunas practically are unknown. The plankton, or that part of the life of the sea which floats at or near its surface, forms only a small part relatively of the total fossil life known. Evidently the life now found in fossil form migrated chiefly along the shallow parts of the sea and most of it could not cross deep waters. In consequence, it is impossible to give any intelligent consideration to the migration of existing or of former faunas without any knowledge of the present or former distribution of the shallow seas, and of the intermediate great ocean deeps. As the result of numerous measurements of the depth of the sea at numerous widely distributed localities it now is very well known that the Atlantic is divided along its entire length, from Iceland to the Antarctic, by a continuous ridge, about equally distant between the two sets of continents eastward and westward, and separated from both sets by equally long and correspondingly deep depressions of the earth's crust. This long median ridge is known as the Atlantic ridge, and it follows in direction the median path between the sinuous outlines of the two sets of continents mentioned. Wegener and his adherents would interpret the great deeps on the two sides of the Atlantic ridge as caused by tension, in which case the Atlantic ridge would represent a narrow strip left between two major fissures, or lines of tension. Recently, however, Henry S. Washington found, on studying the plutonic rocks of the St. Paul's Rocks that these rocks had a sort of gneissoid structure (not gneissoid in color) which suggests crystallization under the influence of lateral compression, which is the exact opposite of tension. Since these St. Paul's rocks lie on the *crest* of the Atlantic ridge, half way between the mouth of the Amazon and the nearest part of the African coast, they suggest that this ridge is of an anticline structure, and that the two deeps on either side represent synclines of an enormous magnitude.

It is of special interest to note that our present knowledge of the sea bottom indicates no trace of a former land connection between South Africa and South America, corresponding to the imaginary land Atlantis.

This leaves for consideration another much mooted problem, that of the wandering of the two poles of our rotating earth. In order to account for the peculiar geographic distribution of certain faunas during past as well as present times on the surface of the earth, certain geologists have attempted to account for these anomalous distributions by imagining a different location for these geographical poles in former ages, with an accompanying shift of the climatic zones. However, this theory leaves out of account certain striking evidences of the presence of poles in remote ages at practically the same locality where they are now. For instance, the circumpolar distribution of the cool temperate tree flora durting Upper Eocene times, already discussed, favors the location of the north geographic pole close to its present position. There was a similar circumpolar distribution of tree life during the Jurassic in the northern hemisphere. In the southern hemisphere, during Permian times, there was a similar circumpolar South Africa, Southeast Brazil and Argentina. Even as early as the Huronian, there appears to have been a circumpolar distribution of glacial conditions in such countries as the southern half of Canada, the northern end of Norway, the Spitzbergen group of islands, and the mouth of the Lena River in Siberia. Such observations on the circumpolar distribution of similar climatic conditions suggest that throughout the known geological history of the earth the location of its geographical poles was at least approximately near their present location.

AN OPTIMISTIC VIEW OF THE EVOLUTION OF SCIENCES.

VIRGIL F. PAYNE,
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The American Association for the Advancement of Science has fifteen sections devoted to the activities of specific science or related groups. Science has been defined as accumulated and accepted knowledge which has been systematized and formulated with reference to the discovery of general truths or the operation of general laws. In this sense a specific science is any branch or department of systematized knowledge considered as a distinct field of investigation or object of study. If we accept this definition the fifteen sections are in reality science sections. In fact, standard dictionaries define all the fields of knowledge represented as sciences except history and the Association itself has designated section "L," Historical and Philological Sciences. This broad view of science and the sciences is the one accepted for the present purpose.

While many fields of knowledge are accepted as sciences, only Physics, Chemistry, Biology, Psychology, Sociology and Economics will be taken as illustrations. For our purpose Physics is defined as that branch of science dealing with those phenomena of inanimate matter involving no change in chemical composition. From the viewpoint of the complexity of original subject matter Physics may be considered the simplest of the sciences mentioned. No doubt, due to this simplicity and the availability of its materials Physics was one of the first bodies of knowledge to be accepted as a science.

Chemistry is defined as the science that treats of the composition of substances, and the transformations which they undergo. Since Chemistry involves transformations in the inanimate matter of Physics, it is to that extent a more involved science. It was as a consequence accepted later as a field of knowledge worthy of the efforts of scholars and as a suitable subject for students. In the sense that art relates to something to be done in contrast to science as something to be known, the art period of alchemy made its contribution to modern chemistry. Likewise the periods of iatrochemistry and of phlogiston made contributions. However, we trace our modern chemistry back more definitely to the work of Lavoisier.

Biology is the science of life; the branch of knowledge which treats of organisms. As such, Biology involves more intricate and elusive subject matter than do Physics and Chemistry. On account of the difficulties involved in establishing controls and in accumulating tested knowledge the workers in the simpler sciences are prone at times to deny the biologist unqualified admission to the science fraternity. The value of Biology and the perseverance and caution of its workers, have however, long since resulted in the establishment of a science of Biology with its various branches.

Psychology is the science of mind; systematic knowledge and investigation of the genesis, powers, and functions of mind. Just as Biology is considered more involved than Physics or Chemistry so in turn Psychology in its pursuit of knowledge of the consciousness of life has had more difficulty in finding its place as a science. The techniques involved in the study of Psychology differ so markedly from those associated with the measuring instruments of Physics, the balance in Chemistry, and the microscope in Biology that we should not be surprised. The fact that the psychologists are so divided by their theories has been a factor in their tardy acceptance. In spite of the reluctance of the older sciences, Psychology has now been generally accepted.

Sociology is defined as the science of the constitution, phenomena, and development of society. Sociology involves the complexities of life and consciousness with all the added difficulties in adjustment attending the interplay of conscious life in groups of various sizes. Many thinkers maintain that Sociology can never be a science but since the time of Comte the claim for this right has made progress. The greatest difficulty individual scientists have is in the recognition of the worth of techniques of scientists in other fields. The statistical method of Sociology with its use of the expression, probability, is almost too much for the older sciences.

The physicist and chemist deal with 25,000,000,000,000,000,000 molecules per cubic centimeter of gas or 33,667,000,000,000,000,000,000 molecules of water per cubic centimeter. They do not face all the hazards the sociologist encounters in individual differences of human beings in a small community. The physicist and chemist, in particular, should be very tolerant of the efforts of the sociologist to determine the statistical significance of the different phenomena observed in small populations.

Economics is the science that investigates the conditions and laws affecting the production, distribution, and consumption of wealth. This science is included not so much because of a logical place in the order of complexity of the other sciences named but more on account of its timely interest. We may judge from the present condition of the world that there is no true science of economics or that the best economists are not trusted and such scientific knowledge as exists is not practiced. This conclusion is obvious in spite of the slowly accumulated and tested knowledge since the writings of Adam Smith in 1776.

It is difficult to divide the sciences into sub-groups. We may call Physics and Chemistry physical sciences, and the others considered biological and social sciences. For the present purpose the older and more commonly accepted sciences of Physics, Chemistry and Biology will be referred to as exact or material sciences, and, the newer and more reluctantly accepted, Psychology, Sociology and Economics will be referred to as social sciences.

A mixture of extravagant praise and equally bitter condemnation has been heaped upon these and other material sciences. These sciences have been commended as making possible the material advantages of our present civilization. They have been blamed for contributing to an increasing disregard for the accepted social values. This machine age has had to face the anomolous charge of bringing hunger to many because of an over-production of food and of depriving many people of the very benefits of the age because too many of these benefits had been produced. It seems only fair to assume that the material sciences have been working effectively and have the power to do much more. They have indeed made possible our material civilization and, in fact, also they make possible the very best social civilization. By them all the necessities and the luxuries are produced with an average individual expenditure of time that allows leisure for transforming the social studies into real sciences.

Our hope then seems to lie not in decreased interest in the material sciences but in using the leisure afforded by them in perfecting the social sciences. We now have much more tested knowledge in Psychology, Sociology and Economics than we are using. We may reasonably hope that intensive, continued reasearch in these fields, equivalent to that given in the past to the material sciences, may produce comparable results. Confidence in the work of the social scientists should result in the establishment of a social order respected and observed by an improved race of people. The economist and sociologist may expect to assume the burden of so organizing society that it would be impossible for over-production and want to exist simultaneously on the earth. The social scientists are ready to assume their responsibilities and the next step is to train a generation that will turn as readily to them for guidance in these fields as the present generation depends on the physicist, the chemist and the biologist. Because of the sobering influence of such a responsibility, we need have little fear of extravagance of promise or action. The accepted sciences may do well to drop their double standard of viewing one group of sciences as exact and another as inexact. They should lead in the unqualified acceptance and encouragement of the social sciences.

If our social order is to come under the dominant influence of science it seems worth while to consider what will happen to some of the arts that have concerned themselves with society. The oldest and most highly respected of these arts is Religion. We have in this art to deal with elements of belief, faith and prejudice which seem diametrically opposed to the cardinal principles of caution, control and tests in science. However, in 1873, F. Max Muller had written an "Introduction to the Science of Religion." We may hope that Religion may eventually be saved for a scientific age by the acceptance of the method of science.

What attitude are we to take concerning the conflicts of theories in the social sciences? We must follow the plan we have always used in the older sciences. The conflicts must serve as a stimulus to more intense and exhaustive research. The conflicting doctrines in science have almost invariably resulted in bitterness—also a great amount of experimental study. It is not possible to condemn too heartily the attitude of the chemist who would get the camel through the eye of the needle by dissolving him in nitric acid and then using a squirt gun.

Finally, a word of caution seems appropriate. Should we displace entirely an old established art such as Religion because it involves some unscientific principles and practices? No more should we discard this art than that of pottery-making while we are developing a science of ceramics. The vessel of the pottery craftsman may be crude. It may contain unnecessary ingredients; some very valuable ingredients may have been omitted, but, if it makes a satisfactory container it has served a useful purpose. Furthermore it is worth while to be reminded again that our oldest sciences such as Chemistry and Astronomy were preceded by the arts, alchemy and astrology. When we feel most certain that we have found the final solution we may well recall Oliver Cromwell's exhortation, "My brethren, by the bowels of Christ I beseech you, bethink you that you may be mistaken."

AUTHORS' ABSTRACTS

OF

SCIENTIFIC PAPERS AND DISCUSSIONS AT THE OXFORD MEETING OF THE OHIO ACADEMY OF SCIENCE ON APRIL 2, 3 AND 4, 1931.

All persons delivering addresses or presenting papers at the Oxford meeting were asked to prepare and submit abstracts for publication in the Proceedings of said meeting. The following have been received by the Secretary in time for inclusion in this report. These are arranged by sections and numbered consecutively for convenience of reference.

A. THE SECTION OF ZOOLOGY.

DR. WENCEL J. KOSTIR, Ohio State University, Columbus, Ohio,
Vice-President.

1. *Micromoving Pictures of the Circulation in Living Bird Embryos.*—By BRADLEY M. PATTEN, Western Reserve University, and (by invitation) THEODORE C. KRAMER, Baldwin Bird Research Laboratory, Cleveland.

(Moving-picture projection.)

Moving pictures of chick embryos during the second day of incubation. Scenes showing the handling of material, manipulation of apparatus, etc. Cuts from films showing the spasmodic intitial contractions of the heart, the beginning of the movement of blood corpuscles in the vessels, and various views of the circulatory mechanism after it has settled into regular rythmic activity.

2. *Laboratory Study of Living Birds.*—By S. PRENTISS BALDWIN, Baldwin Bird Research Laboratory, Gates Mills, Ohio.

This bird laboratory is a growth from the bird banding which has been carried on at this station and at Thomasville, Georgia, since 1914. No attempt is made to collect birds as skins, nor to observe them in groups, but instead the work is all with individuals marked by the numbered bands of the Biological Survey.

From handling many birds it appeared that it is possible to handle eggs, and young birds, and to trap adults freely, without causing them to desert the nests from fear.

Devices for mechanical recording of nest temperatures, and continuous record of activities day and night have been adapted to the work, described in the *Auk*, Vol. XLIV, April, 1927, and other mechanical apparatus for recording access to the nest have been invented and are described in the *Auk*, Vol. XLVII, October, 1930. These make automatic record of incubation, feeding the young and other nesting habits.

With Dr. Kendeigh as Research associate, and other assistants, it is possible to operate four hundred nest boxes, scattered over one hundred estates, handling 250 adult house wrens and twelve hundred young birds in the season, in addition to 2,000 or more other birds from the traps, thus supplying abundant material for the Laboratory.

Studies are made of physiology of birds, body temperature, metabolism, sex differences, as well as incubation, nesting habits, mating, migration and distribution.

Embryology studies are made and in co-operation with Dr. Bradley Patten, of Western Reserve Medical College, a micro-movie has been constructed and Dr. Patten has taken interesting films of the first beginning of heart beat in the developing chick. Apparatus is now being constructed for keeping accurate record of the heart-beat in adult birds under different and controlled conditions.

3. *Regulation of Body Temperature in Birds.*—By S. CHARLES KENDEIGH, Baldwin Bird Research Laboratory and Western Reserve University, Cleveland, Ohio.

Body temperatures of passerine birds are very variable between the limits of 102° and 113° F. This was determined through use of thermocouples and potentiometer pyrometers. The thermocouples were prepared in various ways and used down the throat of the birds and in the nest. Variations in muscular activity cause the most pronounced variations in body temperature. The maintenance of a high body temperature is also dependent upon adequate nutrition. Air temperatures affect the body temperature of the bird in an inverse manner, probably through an influence on metabolism and heat production. Excitement produces a rise in body temperature. The effect of these factors on the bird in nature is shown in the daily rhythm of body temperature, and in daily and seasonal fluctuations. Heat loss from the body seems to be largely controlled through the lungs and air-sacs, since the surface of the body is covered with feathers. The mechanism for regulating heat loss, however, is inadequately developed to compensate for variations in heat production, as caused by the factors above mentioned. This inadequacy may be partly responsible for the higher temperatures of birds over mammals. A consideration of these facts in connection with the development of temperature control in young birds, suggests that homoiothermism could not have developed in the evolution of the class until feathers were evolved and the air-sacs began to expand through the body.

4. *Nesting Success of a Song Sparrow Population in 1930.*—By MARGARET MORSE NICE, Ohio State University, Columbus.

Thirty pairs were studied, 44 of the nesting adults being banded with celluloid and aluminum bands. Fifteen of the adults disappeared during the season, 7 new individuals coming into the area, so that only 25 pairs and two lone males survived in July. Sixty-one nests were found, 32 of which came to premature ends, but 29 raised 102 young. As to the number of successes and failures of 16 pairs that survived the season, one pair had 4 failures and no success, 2 had 1 success and 3 failures, 6 had 1 success and 2 failures, 1 had 2 successes and 2 failures, 5 had 2 successes and 1 failure, while 1 had 3 successes and no failures. Fifteen pairs that survived the season raised the following numbers of young: 0, 2, 2, 3, 3, 3, 4, 4, 4, 4, 5, 6, 7, 7, 10—a total of 64, an average of 4.3 a pair. The nesting season started later than in 1929 and ended early, many of the adults beginning to molt in mid July, completing the molt about two weeks earlier than the previous year. About 38 per cent of the eggs or young were eaten by enemies, 3.5 per cent carried off by boys, 5 per cent lost through cowbirds, 5 per cent lost through parental inefficiency, and 8.6 per cent deserted (in most cases because of the death of the incubating bird). The worst enemies of the young appear to be rats and cats; of the adults, cats and boys.

5. *The Morphology of the Anterior Sympathetic Nervous System of Lumbricus Terrestris.*—By C. G. ROGERS AND T. T. CHEN, Oberlin College, Oberlin, Ohio.

This investigation was undertaken because of differences of opinion expressed by various authors since the work of Clarke in 1856 concerning the existence of an autonomic nervous system in the earthworm. The method used was for the most part simple dissection of worms preserved in alcohol under a binocular microscope under very heavy illumination. This dissection was concerned only with that portion of the autonomic system which might appear upon the wall of the pharynx. Dissections were made from the dorsal, ventral, and lateral aspects, and the portions of the system thus displayed were sketched by means of a camera lucida Some histological preparations stained with Delafield's haemotoxylin and eosin and also various silver and gold chloride preparations were made and examined. The general conclusions were as follows:

1. The sympathetic nervous system of the earthworm consists essentially of three parts: (1) The six nerves connecting the commissure and the gangliated chain. (2) The gangliated chain (3) The two sets of nerve trunks leaving the borders of the chain, one set running anteriorly and the other set posteriorly.

2. The nerve trunks branch freely and usually form enlargements when two meet. These trunks and their branches form a delicate plexus upon the wall of the pharynx.

3. As the plexus runs backward along the esophagus and forward toward the mouth, the nerves become finer and finer and their arrangement becomes more complicated.

4. There is variation diversity in the arrangement of the sympathetic nervous system between individual worms and between the right and left sides of the same worm.

5. The plexus of the right side is continuous around the pharynx with that of the left side.

6. Ganglion cells in the chain of ganglia do not differ from those found in the commissure. Within a ganglion they are located chiefly in the periphery.

6. *Dietary Habits of Barn Owls in Ohio.*—By ARTHUR STUPKA, Ohio State University, Columbus.

The work on this problem was begun in January, 1930, when an accumulation of barn owl pellets. collected from the cavity of a hollow tree on the Ohio State University campus, yielded over 1,100 skulls. Upon examination of this material it was found that the common short-tailed meadow mouse (*Microtus pennsylvanicus*) made up the great bulk of the food of this species of owl. Other mammals included in the pellets were white footed mice, shrews, and rats Birds comprised but two per cent of the entire quantity of skulls. A few months later a still greater accumulation of pellets of the barn owl was collected from the attic of a long deserted school house near Buckeye Lake, Ohio. Over 5,100 skulls were represented in this material. As in the case of the former accumulation, *Microtus pennsylvanicus* made up the bulk of the owls' food. Birds represented but one per cent of the amount.

Later in the year a third accumulation was collected from three localities at Toledo, Ohio This amounted to more than 1,800 skulls Examination of this material showed that the dietary habits of the Toledo barn owls was very similar to that of the barn owls stationed at Columbus and Buckeye Lake Altogether more than 8,200 skulls have been examined to date. Aside from its value in the determination of the economic status of these birds, this study has revealed factors of interest which pertain to the habits and distribution of the fauna represented in the pellets

7. *Parasites of Buckeye Lake Fish*—By RALPH V. BANGHAM, College of Wooster, Wooster, Ohio.

This report is the result of a part of the survey conducted at Buckeye Lake during the summer of 1930 for the Ohio Conservation Department. The ecological conditions were quite different from those in many other lakes. At one location, a pond on Cranberry Isle, peculiar parasite infestation was found. At all of the other locations fish were obtained from the open lake or its tributaries. These were taken at forty seining stations, in the fyke net and in a gill net. Five hundred fish belonging to thirty-eight species were examined. Many were examined while their parasites were yet alive and identifications made as far as possible. All were fixed and several specimens have yet to be stained and mounted for complete identification.

When compared with Ohio stream fish or fish from Lake Erie, the number of species of parasites found in Buckeye Lake was quite low. In few cases was the degree of infestation heavy in any fish. In the case of young gizzard shad with an encysted sporozoan and of several species carrying the gill copepod *Ergasilus versicolor*, there was loss of fish and noticeable lowering of vitality.

Data are given regarding infestation of these fish with protozoa, flukes, cestodes, nematodes, acanthocephala, parasitic copepods and leeches. Comparisons are given for fish not native to the lake which have been planted there, and the infestation of these forms where they are normally found.

8. *A Gilled Oligochaete New to America. Branchiura sowerbyi in Buckeye Lake.*—By Warren P. Spencer, College of Wooster, Wooster, Ohio.

While studying the bottom fauna of Buckeye Lake under the survey made by the Ohio State Department of Conservation in September of 1930, the writer found several specimens of a remarkable annelid worm with a pair of gill-like processes on each of the segments in about the posterior third of the body. This worm, *Branchiura sowerbyi* of the Tubificidæ, has formerly been recorded from the "Victoria regia tank" in the Royal Botanical Society's Gardens, Regents Park, London, the Botanical Gardens of Hamburg and Gottingen, several canals and ponds in France, from India and Japan. This is the first record of *Branchiura* from the western hemisphere.

It was taken at six different stations from the bottom of Buckeye Lake, three of these near Round Island, one near the north shore opposite Round Island, one near Beech and Elm Islands, and one near the south shore between Moonie's and Gibson Islands. This indicates that the worm is fairly well distributed in the central part of the lake. If it is an introduced species it must have been established for several years to have gained its present distribution.

9. *Tanais cavolinii Milne-Edwards (Crustacea).*—By S. R. Williams, Miami University, Oxford, Ohio.

Tanais cavolinii is a small isopod-like form found in salt water near the shore on both sides of the Atlantic.

The group of the Tanaioidea shows relationships to the Amphipods, Cumacea and Mysidacea, as well as to the Isopods. If the Malacostraca be divided into a lower portion, the Pericarida and an upper portion, the Eucarida, then these orders just mentioned show the following characters

PERICARIDA	EUCARIDA
At least four free thoracic somites	Cephalothorax covered by a carapace
Female with brood pouch	Young carried on abdomen
Elongated tubular heart	Short median heart
Few and simple hepatic caeca	Complex liver (hepatopancreas)
Thread-like sperms	Star-shaped sperms
Direct development	A metamorphosis
A movable lacinia on mandible	No lacinia

The Tanaids show the following characters like the Cumacea or Mysidacea: (1) Fusion of the first two thoracic somites with the head instead of one as in most of the Isopoda and Amphipoda. (2) A pair of branchial lamellae (epipodites) attached to the maxillipeds and extending into the branchial chambers under the postero-lateral edges of the carapace. (3) Eyes elevated as though stalked (Mysidacea), but not movable.

Characters like Amphipoda: (1) Anterior thoracic heart, as opposed to more posterior heart in Isopoda. (2) Pleopods (abdominal swimmerets) natatory. Respiratory pleopods in Isopoda.

Characters like Isopoda: (1) General dorso-ventral flattening. (2) Young hatched from egg in brood pouch without last pair of legs or the swimmerets, as opposed to complete young in the Amphipoda.

Character like no close relative: First thoracic legs, gnathopods, chelate.

10. *The Respiratory Apparatus of Parajulus impressus Say.*—By R. A. Hefner, Miami University, Oxford, Ohio.

In general, the respiratory structures of this diplopod consist of the following parts:

(a) Two pairs of spiracles open on each of the segments except some of those in the anterior region. These openings are located antero-laterally to the articulation of the appendages with the body. The spiracles are holopneustic.

(b) Each spiracle leads into a tracheal cavity which expands at the distal end. The hypodermis of the body wall extends into and lines this cavity.

(c) From the distal end of the tracheal cavity lead many (about twenty-five) tracheoles. These extend into the body cavity, many of them continuing through several segments. Scattered nuclei among these tracheoles indicate the cellular origin of the latter.

10a. *Preliminary Report on Phototropic Responses of Drosophila hydeii*—By Walter S. Wilde.

Demonstration of apparatus used in determining the relative phototropic activity of several mutant eye-colored flies of *D. hydeii.* The apparatus used is similar to that employed by McEwen in testing the responses of *D. melanogaster.* Comparative results of wild type and mutant forms of *D. hydeii* are given. This problem will be continued and amplified throughout the coming year.

11. *Notes on the Ecology of Some Grasshoppers of the Genus Melanoplus in Southeastern Ohio.*—By Edward S. Thomas, Ohio State Museum, Columbus, Ohio.

The genus Melanoplus (Orthoptera, Acrididæ) embraces a large number of closely related species of grasshoppers, 17 of which are known from Ohio. Observations, mainly in the hill country of Hocking County, Ohio, indicate that each species occupies its own ecological niche. While two or more species may be found in a given habitat on occasion, this is usually due to overlapping and under optimum conditions, a given species occupies its habitat to the exclusion of other forms. A study of the nymphs will probably furnish the best index of optimum conditions.

Although no species is found in true forest, all of the short-winged forms are essentially sylvan in habit, being found in the vicinity of trees or shrubbery. This is also true of the long-winged form, *keeleri luridus*. *Punctulatus* is our only strictly arboreal species.

Femur-rubrum, *differentialis* and *bivittatus* are characteristic of hydric to mesic habitats; *mexicanus atlanis*, *decoratus*, and *scudderi* of xero-mesophytic; and *confusus*, *luridus*, *obovatipennis*, *punctulatus* and *fasciatus* of xeric situations.

A careful study of limiting factors is required before definite conclusions can be reached. Moisture and temperature are probably most important, although food-plants and the texture, composition and relative acidity of soil may be factors.

12. *Some Observations on the Habits of Passalus cornutus* (*Coleoptera*).—

By WARREN C. MILLER, High School, Bedford, Ohio.

The Passalus beetles make up one of the four families of the series Lamellicornia. Passalus cornutus is the only species found in the United States. It is widely distributed, forming colonies, which make rough, irregular galleries in damp, partly rotten wood such as logs, stumps, sawdust piles, etc.

The beetles are highly social in nature, living with their progeny during the entire period of metamorphosis. Various sex combinations have been found taking care of the young as two females, two males, two females and one male, etc. The adults chew up the wood for food, both for themselves and the larvæ. The larvæ can live without adult care but become dwarfed and the period of development is lengthened. The protective instinct for the care of the young is extremely marked. The adults show fight at the least disturbance.

The larvæ are easily recognized by the peculiar adaptation of the hind pair of legs which form a stridulating organ, thus giving them the appearance of having only two pairs of legs. The period of larval devlopment is very rapid, about six weeks elapsing from first to last instar.

Pupal case building is a cooperative affair between larvæ and adults. The adults assist in the formation of the cases, especially the outsides and keep them in repair during the entire pupal period. The pupal stage is short, averaging ten days, and the newly formed imago is brownish red in color, very soft, but extremely active. The wing covers gradually fuse together precluding any possibility of flying. While the flying wings are well formed there is no evidence for any other use than as an accessory in sound making. From four to eight weeks is necessary for the newly formed adults to change in color to a glossy black.

Cannibalism is present among both adults and larvæ and this accounts for the comparatively small number of larvæ which finally reach maturity.

13. *A Limnological Survey of the Hocking River.* (a) The Plankton of the Hocking—By LEE STEWART ROACH, Ohio University, Athens, Ohio

The Hocking is a swift river traversing a rapidly eroding clay region. The plankton is rather uniformly distributed throughout the length of the river During the autumn Copepoda were the dominant zooplanktonts. The winter dominants were Rotifera. Bacillariaceæ were the dominant phytoplanktont, Cyanophyceæ the least abundant and Chlorophyceæ intermediate. Protozoa were fairly numerous decreasing in the main with an increase in zooplankton, especially Copepoda and Rotifera

Of the factors studied, light, acidity, current, chemical conditions of the water, and temperature, only the latter two showed variation that correspond with changes in plankton.

Temperature range from October to March was 13–1° C. Plankton abundance varied directly with temperature. All phytoplankton varied directly in the same relative proportion. Of the zooplankton Cladocera are apparently the warm water dominants, while Rotifera are the cold water dominants. Copepoda were the dominant medium temperature forms Zooplankton as a whole however decreases and increases directly with the temperature.

The chemical conditions studied varied so little, at the majority of the stations, that no correlation with plankton could be made. However at three stations, below the city of Lancaster the river was undeniably polluted with domestic sewage (as indicated by increased free and albuminoid ammonia, nitrates and nitrites, and decreased oxygen) and there was a direct correlation with plankton. On the whole, total plankton decreases with pollution increase. However Cyanophyceæ increased directly with pollution, as did the Protozoa. Rotifera increased with a certain degree of pollution but diminished with septic conditions.

14 *A Limnological Survey of the Hocking River.* (b) The Bottom Invertebrates of the Hocking—By WILLIAM B. LUDWIG, Ohio University, Athens, Ohio.

The Hocking is interesting limnologically because it is chemically affected by domestic sewage, mine, oil-well, and factory wastes

Forty-seven forms were taken, thirty-five of these being classified to genus and twelve to family only. Chironomidæ and Trichoptera were the most cosmopolitan groups, the latter being uniformly less abundant. The most striking feature concerning the distribution of the other forms was the great abundance of a characteristic type at one or two stations and its scarcity or absence at all others. At two consecutive stations, having domestic pollution, there were 295,000 and 96,000 Tubificidæ respectively per square meter; at another station there were 900 Ancylus; at a third 16,338 Goniobasis; and at still another 1624 of the isopod, Assellus, some amphipods, and 200 leeches.

Oxygen and nitrogen, mainly as albumenoid and free ammonia, were important chemical factors affecting distribution. These factors indicated pollution due to domestic sewage. The pH extremes occurring at different parts of the river were 6.8–7.7. The other important factor correlated with distribution was the substratum. Chironomidæ and Trichoptera were most abundant where there was algæ or solid substratum. The Tubificids depended upon soft, mucky substratum. Goniobasis was most abundant on solid rock. The crustacea and leeches were recovery forms living most abundant where the polluted conditions had improved considerably. May-fly and dragon-fly nymphs and the snail, Ancylus, were present only where there was no indication of pollution. Chironomidæ and Trichoptera became most abundant in these situations.

15. *The Embryology of the Whitefish, Coregonus clupeaformis (Mitchill).*

By John W. Price, Ohio State University, Columbus, Ohio.

This is a preliminary study of the embryology of this important food fish of the Great Lakes, from fertilization to hatching. It is based on a series of 803 egg stages, obtained at the State Fish Hatchery at Put-in-Bay, Ohio, under the direction of the State of Ohio Division of Conservation. The eggs were taken at four hour intervals, day and night, from November 21st, 1926, to April 5th, 1927, a total of 134 days, 16 hours. Temperature readings were taken throughout. In this series, every sixteenth stage was studied both from cleared whole mounts and from serial sections. Stages involving early cleavage, germ ring formation, the primitive streak, the formation and closure of the blastopore and the differentiation of the primary germ layers are described from surface views and from sections. Organogenesis from this point to hatching is shown by reconstructions, which were built up from serial sections projected at 100 diameters on graph paper. They indicate the general development of the brain, sense organs, cranial nerves, notochord, muscle somites, pronephric tubules, the gut, branchial folds, and the heart. While this work is in the nature of a general survey, it should serve as a basis for further study, and yield information useful in attacking various hatchery problems relative to whitefish propagation.

16. *Histology of the Intestinal Tract of Two Minnows, Notemigonus Chrysoleucas (Mitchill)* and *Notropis Atherinoides (Rafinesque)*:—

By Thomas Surrarrer, Baldwin-Wallace College, Berea, Ohio.

It was the purpose of this study to compare both histologically and morphologically the intestine of two minnows *Notemigonus chrysoleucas* and *Notropis atherinoides*. These two forms were chosen because of the decided difference in the lengths of the alimentary canal.

A careful study was made of the length of the gut in relation to the length of the specimen, and the following constants were determined; for *Notemigonus chrysoleucas* 1.25 and for *Notropis atherinoides* .89.

The morphology and histology of the gut and its appendages were carefully studied in both cases; giving special attention to the coils of the gut, the presence or absence of valves, the entrance of the bile and pancreatic ducts, the nature and position of the pancreatic tissue, and a cellular comparison of the various regions of the gut.

Sections were made through the various regions of the canal as well as through the entire viscera, from which the following conclusions were drawn.

CONCLUSIONS.

1. In the study of the two forms no pronounced cellular difference was observed from the esophagus to anus, and both forms seem to be very similar histologically.
2. The entrance of the bile duct is well toward the anterior end of the stomach.
3. The processes of digestion are undoubtedly the same throughout the gut.
4. The goblet cells are present in the region of the stomach.
5. The stomach region possesses a thin wall.
6. Both forms are without pyloric valves.

(a) The above six facts seem to prove rather conclusively the absence of a stomach.

(b) The rather numerous regular folds throughout the gut of atherinoides, proves its large absorbing surface and may account in part for the shortness of the canal.

(c) Both forms possess a pancreas that is distributed through the mesenteries, and which is neither surrounded nor dispersed in the liver substance.

(d) Pancreatic ducts enter the common bile duct; and minute ducts seem to enter at irregular intervals along the canal.

16a. *Skinning Our Parks.*—By S. PRENTISS BALDWIN, Baldwin Bird Research Laboratory, Gates Mills, Ohio.

During the last year, the attempt to provide work for the unemployed has, in many cities, intensified an old problem of park management.

Too often the official order to provide work to the unemployed takes the form of *cleaning up* the park.

Now this "clean up" means to the average man, to cut down all undergrowth, cut out every dead tree, dig every stump, and burn all the brush and it results in a clean shave as to any possible cover or hiding place for wild life, either birds or mammals. I have recently seen twenty acres of beautiful little valley park, on the edge of a city, so skinned that a rabbit could not hide in it.

Park officials and even landscape architects often do not realize that very few birds nest higher than fifteen feet above ground, and many nest on the ground or within five feet of it.

Few, again, appreciate that in cleaning level spaces in the park for recreation, the rougher parts of the park will prove far more interesting if the wild flowers, as well as the birds and small mammals are allowed to live and associate with the human population.

An argument for skinning is often heard, that for protection of women and children from rowdies, it is necessary to remove every shrub or shelter. No doubt there is often good reason for the argument, but plant, then, groups and clumps of thorn bushes, wild roses, wild blackberry, barberry and other low cover, and by all means leave the leaves in the autumn to rot and feed the trees and shrubs.

This is an appeal to nature lovers to keep your eyes on the parks and persuade the authorities in charge to allow the smaller wild life to live, and join in mutual interest in the association of human life in the parks.

17. *The Heronries of Northern Ohio* — By E. L. MOSELY, State Normal College, Bowling Green, Ohio.

In the woods of Horatio Wagner, fifteen miles west of Sandusky Bay, great blue herons have built their nests and reared their young since 1913. Having been protected, they have increased, so that there are now 450 nests, all high up in tall trees. More than a thousand eggs probably hatch in these nests each year. The young are fed with fish regurgitated by the parents. To supply so many hungry mouths may require a ton of fish a day. Carp, sheepshead, goldfish and other species are brought from long distances.

Nearer to Sandusky Bay the birds have started a new heronry not far from the automobile road which leads from the south to the bridge across the bay. This and other nesting places for these great birds may prevent further increase in the number resorting to the Wagner woods.

The herons begin arriving in northern Ohio about the middle of March and soon start repairing the old nests. The Wagner heronry is deserted in August, but many of the herons are seen along the streams and marshes until October or November.

B. THE SECTION OF BOTANY.

DR. J. HOBART HOSKINS, University of Cincinnati, Cincinnati, Ohio,
Vice-President.

18. *Some Poisonous Plants Indigenous to Indiana.*—By GEORGE W. FINLEY, Brazil, Indiana

During the recent past, much land, formerly cultivated, has been abandoned, practically, and reforestation is gradually restoring conditions favorable to undergrowth of shade-loving wild plants. A great deal of this is very desirable, but it also includes many species harmful to man and domestic animals. A large part of the present population is quite ignorant of outdoor life in its natural environment, and must learn by painful experience.

People flock to our state parks and other forest areas for recreation, and by idle curiosity meet with grief by careless experimenting with unknown forms of plant growth. A few plants capable of causing illness, varying in severity from temporary to chronic disability, or in exceptional cases, fatal, will be mentioned.

Atropa belladonna: The deadly nightshade. Its attractive berries eaten by children may be fatal. First aid in tannic acid infusion and emesis. Physican should be called promptly.

Aconitum napellus: Wolf's bane, or monk's hood. This is a most potent vegetable poison. The rootlets have been mistaken for horse-radish. Antidote, digitalis, administered hypodermically.

Amanita muscaria and *A. phalloides* contain a poisonous alkaloid not altered by cooking which may cause fatality with great suffering unless counteracted by proper antidotes such as atropine

Conium maculatum: Swamp hemlock. Falsely called wild parsnip. Dangerous to live stock. Persons have been sickened by tasting this for ginseng

Eupatorium urticaefolium: White snakeroot. When eaten by grazing animals produces a disease known as "trembles," and was the once mysterious cause of "milk sickness" Formerly caused heavy losses in grazing animals in the middle west.

Datura Stramonium: Flower, mature seed and foliage dangerous to children.

Papaver somniferum: The common poppy yields its narcotic opium from the milky juice of the plant and green seed pods. Ripe seeds furnish an edible oil

Phytolacca decandra: Pokeroot has caused serious illness in children who mistook it for parsnip.

Gelsemium sempervirens: Yellow Jessamine, and *Sanguinaria canadensis* have an acrid poisonous substance in the rhizome only

The following cause violent dermatitis: *Rhus Toxicodendron, R. venenata, R. diversiloba* and *Urtica dioica.*

19. *Freshwater Algæ of Southern Florida*—By L. H. TIFFANY, The Ohio State University, Columbus, Ohio

Some 300 collections of freshwater algæ were made in Southern Florida from Jan. 15 to Mar. 15, 1931. Most of the collecting occurred in the counties of Lee, Charlotte, Collier, Hendry and Glades, although some samples were secured in the everglades and in freshwater pools of the Keys. Desmids were very plentiful in most collections indicating a rather extensive desmid flora in a region that is geologically quite young. Particular attention has thus far been paid, in analyzing the collections, to the Oedogoniacæ and Zygnemaceæ. Species of these algal families occurred most plentifully in permanent pools and ponds and in the cypress swamps. A few forms of Oedogonium and Mougeotia occurred in drainage canals. The larger lakes contained very few species of either of the above families. Twenty-two different species of Oedogonium were identified from a single cypress swamp south of Arcadia. A considerable number of species of Bulbochaete, Spirogyra, Oedogonium, and Mougeotia, previously reported only from South America, occurred in the Florida collections. A comprehensive account of the survey will appear later.

20. *Pollen Analysis of Bacon's Swamp at Indianapolis Evidence of Two Dry Climates in Post Wisconsin Time.*—By PAUL B. SEARS, University of Oklahoma, Oklahoma, Okla., and ADOLPH E. WALLER, Ohio State University, Columbus, Ohio.

The preservation of pollen under the acid conditions of peat offers a clue to vegetation changes in our limestone regions of the Central States. It has been assumed that the retreat of the glaciers was followed by a migration of vegetation confined during the period of claciation to warmer and drier regions. The evidence from pollens presents a more detailed and slightly different story. There have been two dry climatic periods instead of one as heretofore supposed.

Peat studies in the Bacon Swamp show that dry climates existed at the 17 foot level and again at the 5 foot level. At both of these levels grass pollens are abundant. The climate was similar to that now prevailing in some of the grassland regions of the United States. But at the 17 foot level the cool character of the dry climate is attested by birch pollen and by the pollen of closely related alder and hazel, and by spruce and larch pollen.

The warm character of the succeeding climate is attested by the increase of hickory pollen and the decrease of birch pollen. A narrow deposit of pine pollen at the 5 foot level is a good indicator of drying in this period.

A measure of fluctuations in humidity is offered by beech. The beech maxima appear at the 10 foot and 1 foot levels. This shows a reciprocal relation with the grass pollen numbers which are least for these levels. The absence of beech pollen at the 17 and the five foot levels are also highly significant. A slight increase of beech and a decrease of grassland pollen at the 15 foot level suggests that the change from the 17 foot dry condition to the 10 foot humid condition was not necessarily steady.

21. *The Correlation Between Dry Weather and the Storage of Organic Reserves in Alfalfa Roots.*—By C. J. WILLARD, Ohio Agricultural Experiment Station, Wooster, and Ohio State University, Columbus, Ohio.

It has long been known in practice that west of the Missouri River alfalfa can be cut more frequently and at an earlier stage with less injury to the stand than in Ohio. Observations during the dry season of 1930 gave the key to the reason for this. From April 1 to June 15 the rainfall on the Ohio State University farm was 2.74 inches, compared to a normal of 8.08 inches for that period. The average growth of alfalfa hay from May 1 to June 5-14, based on six samples, was only 870 pounds per acre, or 25 pounds per acre per day. However, in the same period the roots gained 1190 pounds per acre (air dry weight) or an average of 34 pounds per acre per day. This compares with 22 pounds per acre per day as the highest previous gain in roots during approximately this period, and a normal figure very much less than this.

In November, 1930, nineteen plots of alfalfa, sown in 1928, averaged 4155 pounds of air-dry roots per acre. The same plots in 1929 averaged 2663 pounds. Records from all over the State showed similar results, the average of 138 samples from five stations being 3560 pounds of roots per acre. Throughout 1930, plots cut frequently recovered vigorously, whereas they do not in a normal season. In 1930 the 4-cutting plots at Columbus went in the winter with an average of 3040 pounds of roots and the 3-cutting plots 3400 pounds. As an average of the 4 preceding seasons these figures were 1750 and 2630 pounds respectively.

Taking all records of 34 days or over secured in our work since 1925, a total of 61 comparisons, the correlation between average daily root storage and average daily rainfall was —.44±.07.

All these facts go to show that in a dry season a larger proportion of the materials produced by photosynthesis will be stored in the roots and a smaller proportion used for top growth than in a wet season. Consequently, in a dry climate, alfalfa can be cut with far less attention to maintaining root reserves than is possible in the normal climate of Ohio. Also, alfalfa sown in Ohio before 1930 went into the winter of 1930-31 in better condition to resist winter-killing and make large yields the next season than in any season for the past 8 years.

22. *Absorption of Water by Root Systems of Plants.*—By PAUL J. KRAMER, Ohio State University, Columbus, Ohio.

The purpose of this work was to throw additional light on the role of the living cells of the root in the absorption of water and in the development of root pressure. The complex of factors bringing about the absorption of water in transpiring plants seems to be quite different from that operating in plants in which little or no transpiration is occurring.

Experiments in which the pull of the transpiration stream was replaced by the tension developed by a suction pump attached to the cut stem of the plant indicated that reducing the pressure within the conducting vessels materially increased the absorption of water. It appears that the movement of water from the soil into the conducting vessels of the roots of transpiring plants results from the difference in pressure inside and outside the plant. This difference in pressure is the direct result of the tension set up in the hydrostatic system by transpiration. Such a process reduces the role of the living cells of the root to that of mere absorbing surfaces, a role which, in some respects, might as well be filled by dead as by living cells. Experiments indicate that in moist soils as much or more water may be absorbed through a dead as through a living root system.

Positive pressures apparently are manifested only when living cells are present in the root. Experimental evidence supports the view that in plants in which little or no transpiration is occurring water moves from the soil to the dilute solution in the conducting vessels of the root by osmosis across a differently permeable membrane formed by the living cells of the root.

23. *The Loss in Dry Matter in Sweet Clover Roots from Fall to Spring.*—By C. J. **Willard**, Department of Agronomy, Ohio Agricultural Experiment Station; Department of Farm Crops, Ohio State University, Columbus, Ohio.

In the course of studies on the life history of sweet clover, it was discovered that there is a very considerable loss in the weight of dry matter in sweet clover roots from fall to spring, and some special studies were made to determine its amount. As an average of 87 comparisons extending over four seasons, we found 2065 pounds of air-dry sweet clover roots per acre in November and 1728 pounds in the early spring, an average loss of 347 pounds or 16.8 percent. This loss almost certainly measured the amount of material used in respiration during the winter. It was not due to variations in stand or losses of whole plants, for the November samples averaged 169 plants per square yard and the spring samples 173 plants.

That this loss is from respiration is borne out by the percentage of nitrogen in the roots in the fall and spring. This nitrogen would not be used up in respiration, and as a result of using up carbohydrate materials, the roots should contain a higher percentage of nitrogen. As an average of six years, involving 38 comparisons, sweet clover roots contained 3.47 per cent of nitrogen in November and 4.34 per cent in March or early April following. The nitrogen per acre in the roots, as calculated from the average figures above, is 72 pounds per acre in the fall and 75 pounds per acre in the spring.

The hydration of sweet clover roots changes markedly from fall to spring. Over four seasons, the air-dry weight has averaged 33.4 per cent of the green weight in the fall and only 19.0 per cent of the green weight in the spring. Applying these percentages to the average dry weights above, the average green weight of roots in the fall was 6180 pounds per acre, and in the spring 9090 pounds per acre. Thus the green weight increased while the dry matter decreased.

C. THE SECTION OF GEOLOGY.

Dr. Frank J. Wright, Denison University, Granville, Ohio,
Vice-President.

24. *The Gratz Division of the Cynthiana Series of Central Kentucky.*—By J. J. **Wolford**, Miami University, Oxford, Ohio.

The Gratz division of the Cynthiana series is typically represented near the village of Gratz, Owen County, Kentucky. It was first recognized about 30 years ago by Dr. E. O. Ulrich, and subsequently classified as a sub-division of the Cynthiana series by Dr. R. S. Bassler in U. S. National Museum Bulletin 92. Although the Gratz division has been referred to several times by geologists, it has never been studied in detail or even accurately defined.

The Gratz division consists typically of 49 feet 6 inches of fairly even-bedded, blue shale with numerous thin layers of argillaceous limestone. It exists, in its type locality, between the predominantly limestone Bromley division below, and the Eden shale above. The relationship with the Bromley division is one of conformity. Indications at the top of the Gratz division, however, point to at least a shoaling of the sea at this stage, and probably a disconformity between the Gratz and the succeeding Eden sub-series

The fauna of the Gratz division is very similar to that of the underlying Bromley strata, but it is notably different from that of the Eden sub-series, although the latter strata are lithologically similar to those of the Gratz division.

In conclusion, the preponderance of evidence indicates that the Gratz division is closely related to the underlying Bromley division In contrast, the relationship with the Eden division is one of unconformity.

25. *The Devonian Corals of Ohio.*—By GRACE A. STEWART, Ohio State University, Columbus, Ohio.

The corals in the Devonian rocks of Ohio are found distributed throughout the various subdivisions of this system of rocks By far the greater number occur in the Columbus limestone, and they are particularly abundant in the so-called "coral layer" of the formation. One hundred and twelve species have been listed from the entire system. This number is somewhat over-estimated, however, because in a number of cases the species reported are merely synonyms of others. Eleven new species have been based on Ohio material. The corals are preserved both in a calcified and a silicified condition, the latter being found principally along joint planes and on weathered surfaces The calcified corals are much more valuable for determination than the silicified ones because the structure is much better preserved.

The Devonian corals of the state have never been studied comprehensively as a group before. Hence the purpose of [illegible] present study is to bring together the scattered information already known regarding the corals, and to describe and illustrate the entire coral fauna. During the progress of the work six new species have been recognized.

26. *The Horizon of the Brassfield Limestone in Southeastern Ohio.*—By JAMES W. CUMMINS, The Pure Oil Company, Columbus, Ohio.

The Brassfield Limestone is shown by a series of cross-sections to underly the Clinton limestone of New York at a depth of from twenty to forty feet. These sections drawn through wells drilled in Jackson, Vinton, Lawrence, and Gallia counties show the Clinton to thin towards the west and the Brassfield to thin towards the east.

If this correlation is correct the upper part of the Alger shale is the equivalent of the Rochester shale of New York, and the lower part of the Alger shale is the equivalent of the Clinton limestone of New York. The Brassfield is then the equivalent of the upper part of the Medina formation of New York state. Other well records are cited which support this correlation.

27. *The Origin of Limestone Caverns.*—By A. C. SWINNERTON, Antioch College, Yellow Springs, Ohio.

The two-cycle hypothesis proposed recently by Davis to explain the origin of large caverns in limestone is compared with the hypothesis which was proposed by the writer in 1929, that cavern systems are excavated in the zone of lateral discharge in the fluctuating upper portion of the water table. The Davis view is based on King's concept of ground water circulation, while the writer's view is patterned after J. W. Finch.

A physiographic test which depends upon the direction of flow of the deep-seated circulation is proposed. The application of the test to the orientation of Mammoth Cave and Great Onyx Cave to the Green River implies that the deep-seated circulation is not effective in the formation of integrated cavern systems.

28. *Recent Formation of Dolomite in an Ohio Cave.*—By RICHARD C. LORD, Kenyon College, Gambier, Ohio.

The synthesis of dolomite in the laboratory under the conditions similar to its formation in nature has only recently been accomplished by procedures that can be duplicated by others. Based on personal experience with Ohio brines, and work of Mitchell, of University College, London, and Johnson, of Carnegie Institute, Washington, the writer suggests the possibility of precipitating magnesium when the partial pressure of carbon dioxide in the solution is very low, with consequent lowering of the hydrogen ion concentration. Ammonia and Hydrogen sulfid, which may be present when dolomite is formed, both tend to lower hydrogen ion concentration. Iron is also readily precipitated under conditions of low hydrogen ion concentration and traces of iron are usually found associated with dolomite. Analyses of occurrence of a high calcium stalactite and a high magnesium red sediment from the Ohio Caverns are given in substantiation of this theory.

29. *Some Temperature Abnormalities in Indiana and Kentucky Highs.*—By ROBERT KENDALL AND ERNEST RICE SMITH, De Paw University.

Attention was called to this problem by a recognized minimum temperature at Greencastle, Indiana, December 20, 1929, which was twelve degrees lower than any other record in the State of Indiana. Temperature conditions in high-pressure areas are usually considered to be comparatively uniform. Variations are generally considered to be due to: topographic relief, cloudiness, wind, city effect, and snow covering. Maps illustrating variations over a period of more than thirty years in Kentucky and Indiana indicate the probability that there are other causes of variation and that more accurate and complete data from cooperative weather observers are needed. Not only maxima and minima, but also the time of such records and the relation to barometric pressure would aid in the solution of this problem. It is suggested that in each state, the United States Weather Bureau supply competent cooperative observers with thermographs, barographs and mercurial barometers to give more complete data.

30. *The Finns in Ohio.*—By EUGENE VAN CLEEF, Ohio State University, Columbus, Ohio.

The mere presence of the Finns in Ohio is not in itself a matter of particular significance. However, when considered in the light of the distribution of Finns in other parts of the United States, these settlements warrant detailed investigation.

From studies among the Finns in the Lake Superior District and in New England, subsequently compared with investigations made in Finland, the writer arrived at certain definite conclusions with respect to the response of Finnish life to its physical environment. The Ohio Finns reveal what seems at first to be exceptions to the rule. If, on the other hand, the activities of the Ohio Finns represent merely an advanced stage in the settlement of a foreign group in the United States, then we may interpret them as normal.

The problem at hand is one which if solved, should contribute much toward a better understanding of settlement. Through such investigations, some light may be shed upon a possible scientific adjustment of migrating peoples to specific environments.

31. *Erosion Surfaces in Eastern Ohio.*—By KARL VER STEEG, College of Wooster, Wooster, Ohio.

Projected profiles and field study of an area of approximately 4,000 square miles in the rugged, unglaciated portion of eastern Ohio, indicate the presence of two well-defined erosion surfaces, the Harrisburg on the uplands and stream divides, at an average elevation of 1,200 to 1,300 feet a.t. and the Worthington (Lexington) at an altitude varying from 900 to 1,100 feet a.t. The Harrisburg in Ohio is correlated with the Allegheny Plateau upland in Pennsylvania. The Worthington in eastern Ohio is correlated with the Kentucky Lowland (900 to 1,000 feet a.t.), located west of the conglomerate escarpment. This area, of which the Lexington Plain is a part, slopes westward and is co-extensive with the lowlands in western Ohio, much of which lies at about 900 feet a.t.

The writer recognizes the existence of three distinct erosion surfaces in the northern Appalachians and Allegheny Plateau region; the Schooley (Kittatinny) on the ridge crests of the folded Appalachians, the Harrisburg on the weaker rock formations in the valleys of eastern Pennsylvania and co-extensive with the upland erosion surface beveling the Allegheny Plateau region and a third, the Worthington (Lexington) erosion level, well developed in Ohio and Kentucky, and which by virtue of its position below the Harrisburg is correlated with the Somerville of eastern Pennsylvania and New Jersey. This seems to the writer to be the most logical interpretation, in the light of present knowledge concerning Appalachian erosion surfaces.

32. *Paragenetic Relations of Galena-Sphalerite.*—By RALPH TUCK, University of Cincinnati, Cincinnati, Ohio.

Examination of galena-sphalerite intergrowths offer an attractive field of investigation of the influence of varying physical-chemical conditions on the order of crystallization and the boundary relations between sulfide minerals, as galena and sphalerite occur in deposits ranging from high to low temperature and pressure.

The usual order of crystallization in the intermediate to deep vein deposits is either that galena and sphalerite are contemporaneous or else the sphalerite precedes the galena, but rarely is there evidence of the galena preceding the sphalerite. As a rule solution boundaries as evidence of paragenesis must be used only with extreme caution and it is more common to find the replacing mineral which is usually galena showing concave outlines towards the sphalerite, instead of convex boundaries as has been suggested by some authors.

Many of the intergrowths from our intermediate to deep vein deposits show such a uniformity in the mixture of the two minerals and such overlapping in period of crystallization that it strongly suggests that the crystallization was initiated from a number of centers.

It is believed that the boundaries exhibited by sphalerite and galena can be in part attributed to rate of cooling. If the cooling is relatively rapid, there will be little if any separation of the galena and therefore the polished section will indicate a contemporaneous crystallization. When the cooling is slow fractionation will be more complete and there will be more evidence of replacement and later deposition of the galena.

It is in the lead-zinc deposits that we find the best examples of zonal arrangement and it seems probable that there is a relation between it and the mutual boundaries exhibited by the sulfides.

33. *Announcement of Plans for the Field Trip.*—By FRANK J. WRIGHT, Denison University, Granville, Ohio.

The annual spring field trip of the geology section of the Ohio Academy of Science will be held May 29–31, 1931. In view of the fact that Memorial Day falls this year on Saturday, most of the work will be planned for Saturday, and Sunday forenoon. The Hocking County conglomerate area will be studied under the guidance of Professor J. E. Hyde of Western Reserve University, who will have entire charge of the excursion. The party will assemble at Lancaster.

34. *A Remarkable Fossiliferous Lens in the Bainbridge Limestone.*—By PAUL H. DUNN, Miami University, Oxford, Ohio.

The Bainbridge Limestone of Southeastern Missouri is described by J. R. Ball in an unpublished report of the Missouri Geological Survey. An outcrop in Ste. Genevieve County, along the Ozora-St. Marys road south of the Greither Hills, and near the University of Chicago Field Station, gives the maximum thickness of the formation as well as the area of the most abundant fauna.

In this outcrop there is exposed one hundred and twenty feet of the characteristic Bainbridge, brick-red, argilaceous limestone and calcareous shale. A lens of greyish-white, in many places coarsely crystalline, massive limestone, five feet thick and six hundred feet long, however, occurs about fifty feet below the top of the formation. This lens carries an abundant fauna characterized by *Merista tennesseensis*. The fossils are in most cases external casts of waxy-white calcite.

Another fossiliferous zone, characterized by a *Pisocrinus* fauna, is found fifteen feet beneath the base of the crystalline limestone.

In other localities the Bainbridge is sparingly fossiliferous or devoid of organic remains.

35. *The Foraminifera of the Bainbridge.* †—By Paul H. Dunn, Miami University, Oxford, Ohio.

A by-product of the foregoing work which undoubtedly is of greater importance than the actual study itself was the discovery of a number of species of foraminifera in the residue of each sample. W. L. Moreman, who has recently* announced the only other known occurrence of foraminifera in the Silurian of this country, has described and figured several species of arenaceous foraminifera from the Arbuckle (Ordovician), Viola and Chimney Hill (Silurian) limestones of the Arbuckle Mountain region.

As the forms found in the Bainbridge are similar to those discovered by Moreman, there is opened up the strong possibility of accurate foraminiferal correlation of the Bainbridge with the Silurian formations of the southwest.

The detailed results of this study will be published later.

36. *Pre-Mesozoic Stratigraphy of the Central Wasatch Mountains.*—By A. A. L. Mathews, Oberlin College, Oberlin, Ohio.

The Pre-Mesozoic stratigraphic section of the Central Wasatch Mountains comprises sedimentary strata ranging from Archean to Permian. It is over four miles thick and consists of sedimentary, metamorphic and igneous rocks

Several well defined and characteristic unconformities are involved in the groups, showing post-Archeozoic and pre-Mesozoic structures. Many low angle unconformities occur and several erosional breaks are apparent.

The limestones and shales were deposited horizontally under marine conditions; some of the conglomerates and sandstones were laid down along old shores, and the entire mass since deposition and induration has been subjected to orogenic movements, which were followed by erosion, thus exposing the truncated edges of the strata.

The Archeozoic era is represented by an excellent exposure of the characteristic basal complex; the Proterozoic by the characteristic pre-Cambrian quartzites and slates, and the Paleozoic by the Brigham quartzite, Ophir shale, undifferentiated Cambrian and Ordovician limestones, Swans Peak quartzite, Jefferson limestone, Three Forks limestone, Madison limestone, Morgan formation, Brazer limestone, Weber formation, Park City formation and the Phosphoria formation.

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†These studies were carried on at the Walker Museum, University of Chicago, under the direction of Carey Croneis.

*Journal of Paleontology, Vol. IV, No. 1, March, 1930.

37. *The Earliest Known Cephalopods of America, Europe and Asia.*—

By AUG. F. FOERSTE, Dayton, Ohio.

The oldest known cephalopod in Asia is a very small curved species described by Walcott from the Tsinan area, southwest of Peiping, in eastern China, from the Upper Cambrian, under the name *Cyrtoceras cambrica*. Farther north, in southern Manchuria, another curved form, related to *Piloceras*, occurs in strata of Canadian age.

In Europe, the oldest known species definitely known to be a cephalopod is that described by Broegger from the Ceratopyge limestone of Norway, directly over the Cambrian, under the name *Orthoceras attavus*. This species has a straight annulated conch with transversely striated surface; its siphuncle is very small and located close to the ventral wall of the conch. Its nearest relative is a species occurring in the Canadian of Arkansas, and the Norwegian horizon is regarded as also of Canadian age. The peculiar species used as the genotype of *Volborthella*, found in the Upper Cambrian of Finland and of Esthonia, appears to have a small central siphuncle, and in this respect differs from all the earlier cephalopods known from any area in the world. Notwithstanding its strikingly orthoceroid appearance, its affinities with typical cephalopods are not fully established.

In America, the oldest known cephalopod is a straight, laterally compressed, and transversely ribbed conch, apparently related to the genus *Walcottoceras*. It occurs in the Lower Ozarkian of Oklahoma. The Middle Ozarkian of Arkansas and Missouri contains chiefly curved conchs with relatively large siphuncles along their concave outlines. In the Upper Ozarkian straight endoceroids are not uncommon, but are represented by fewer genera than the straight forms.

In general, Cambrian and Ozarkian cephalopods are characterized by siphuncles which either are in contact with the ventral wall of the conch or at least are located near the latter. In the curved species, the siphuncle always is on the concavely curved side of the conch. The great preponderance of curved genera suggests that the earliest cephalopods may have been curved forms. Almost all of these earlier forms apparently belong to the Holochoanoidea.

The single exception known so far appears to be *Volborthella*, which has a central passage through the septa, possibly representing a siphuncle. In that case it would belong to the Ellipochoanoidea, which elsewhere are not known until the Upper Canadian.

It can not be determined at present whether the Holochoanoidea or the Ellipochoanoidea are to be regarded as the more primitive cephalopods. If the Norwegian species *Orthoceras attavus* could be ignored, the evidence would be in favor of the Holochoanoidea. As far as the straight and the curved forms among the Holochoanoidea are concerned, it is equally uncertain which of these are to be regarded as the more primitive, but, judging from the much wider range of generic variation among the curved forms, the latter are regarded provisionally as the more primitive, especially since the amount of their curvature usually decreases with increasing maturity.

38. *The Status of Paleobotany in Ohio*—By WILLARD BERRY, Ohio State University, Columbus, Ohio.

During the last four decades there has been little or no work done and published on the fossil plants of Ohio. Since the death of the earlier workers and the publication of the several volumes on paleontology by the Ohio Geological Survey there has been little interest shown in the subject in this State. The mining out of the Youngstown and other important coal areas and the burning of the coal around Shawnee possibly has had something to do with it. There have been a few sporadic attempts at a revival of interest but nothing of importance has come of it. Recently however several fresh starts have been made.

Dr. J. H. Hoskins of the University is studying the fossil trunks of Psaronius and I have begun the study of floral remains from the Carboniferous for the Geological Survey of Ohio.

From various sources it would seem that there existed at one time several large collections of fossil plants from Ohio. Herzer's collections are in part in Washington, D. C.; J. S. Newberry's collections are in New York; of the others only rumors seem to be extant. Lesquereux mentions a "Cabinet" of Dr. Orton's; there was a collection by Andrews of about 30,000 specimens; these are now at Marietta College. There were undoubtedly other collections but what has become of them is a question

Ohio is especially well suited for the study of Carboniferous plant fossils due to the numerous coal and clay beds overlayed by shale and clay. In this respect we are much more fortunate than our neighbors either Pennsylvania, West Virginia or Illinois.

A complete revision of the Carboniferous plants of Ohio is in progress and any information regarding existing collections will be much appreciated.

39. *Fossil Footprints From the Pennsylvanian.*—By ROBERT H. MITCHELL, Muskingum College, New Concord, Ohio.

At Senecaville, Ohio, in the Cleveland Mine of the Cambridge Collieries there is a remarkable number of fossil footprints. These prints are in the shale above the Upper Freeport or number 7 coal. At a number of places in the roof of the mine the prints are abundant and are fillings of the impressions of the animal's foot.

Perhaps the best preserved prints from this mine are now in the collection of Muskingum College. There are two slabs of the shale, one about one foot and two inches by three feet and nine inches, and contains thirteen prints or parts of prints. These prints are impressions. The other slab is five feet and five inches by one foot and eight inches and contains sixteen prints or parts of prints. The tracks on this slab are fillings of the impressions and stand out in relief. They are less well preserved than those of the imprints and are more typical of those found on the roof of the mine.

The size of the prints and the shape of those best preserved resemble very closely Ancylopus ortoni Carman.

40. *Is Orogenic Deformation Continuous or Discontinuous for the Earth as a Whole?*—By WALTER H. BUCHER, University of Cincinnati, Cincinnati, Ohio.

Recently, von der Gracht wrote: "It becomes ever more apparent all over the world that it is a general rule that in all geosynclinal basins, folding . . . . increases with depth . . . .. This is caused by progressive folding during sedimentation . . . .." He implies that such orogenetic folding may have continued through as much as a whole period. As concrete illustration he quotes the work of a German mining engineer, H. Boettcher, in the coal-bearing Pennsylvanian of Westphalia. For these beds, about 10,000 feet thick, "he proves that progressive folding throughout the section caused accumulation of 63 per cent more sediment in synclinal folds than the normal thickness would call for . . . .. This is exclusive of posterior increase and reduction of shales through the mechanism of folding or otherwise after sedimentation." (Bull. A. A. Petrol Geol., vol. 10, 1926, p. 427).

In a paper entitled "To Question the Theory of Periodic Diastrophism," Shepard reasoned on the assumption that "the time of diastrophism was . . . . not . . . . a point of time, but . . . . extended over a considerable fraction of a period, let us say on the average about a third of a period." He thinks "no harm was done in making such an assumption, because it is becoming well recognized that orogeny is not as brief a process as it was formerly considered." (Jour. Geol., vol. 31, 1923, p. 602).

If orogenic deformation is an act which extends through large fractions of periods, then it may well have been a continuous process as far as the earth as a whole is concerned, since for all periods (except perhaps the Cambrian) one or several orogenic movements have been recorded from some part of the earth or other.

The question involved is of sufficient interest to warrant careful study. In his address, the writer explained the observations on which Boettcher based his conclusions. He showed that the conclusions are valid only if anticlines and synclines have equivalent geometrical form. In the case studied by Boettcher, this is strikingly not the case and his far-reaching inference is, therefore, not valid.

In all carefully studied regions, such as the Paleozoic portion of the Appalachians, there is good evidence that orogenic deformation began after the now accessible sediments had been laid down. Furthermore, wherever it is stratigraphically possible, the length of time involved in the orogenic deformation can be shown to have been short in comparison to the length of the average period.

But even if locally orogenic epochs occupy but a small fraction of a period, orogenic deformation might have been under way somewhere on the earth at every instant of geologic time. That this is not the case is becoming more and more clear as the number of accurate time records of orogenic movements from all parts of the earth increases. The progress of accurate timing was illustrated by a discussion of the tables of orogenic epochs prepared by R. T. Chamberlin, Blackwelder, and Stille, and by a number of detailed examples.

41. *A Comparison of the Maine and Connecticut Shorelines.*—By HENRY S. SHARP, Denison University, Granville, Ohio.

Due to submergence the shorelines of Maine and Connecticut are very irregular, but the difference in their irregularity is so great that in comparison with the coast of Maine the Connecticut shoreline might almost be described as rectilinear. If the shorelines of both states were straight, Maine's would be slightly more than twice as long as Connecticut's. The shoreline of Maine measures 1,319 miles, that of Connecticut 144 miles in length, so that actually the Maine shoreline proves to be over nine times longer, or roughly four and one half times more irregular than the Connecticut shoreline.

A number of causes may be advanced to account for this marked contrast. Of these the following, dependent upon the presence of a different peneplane at the shore in Connecticut than in Maine, are believed to be most important. The more steeply a peneplane slopes into the sea, the more regular shore will it form; in Connecticut the submerged peneplane slopes southward 50 feet per mile, in Maine 15 feet. The more dissected the surface, the more irregular shoreline will it form when submerged; in Connecticut the Fall Zone peneplane is much less dissected than the New England Upland peneplane in Maine.

42. *Industrial Adjustments in the Miami Valley.*—By A. J. WRIGHT, Ohio State University, Columbus, Ohio.

The Miami Valley in southwestern Ohio challenges the interest of economic geographers; first, because of the importance of manufacturing as a livelihood in this famous farming region; second, because of their continuing sectional importance in Ohio's indrustial production; and third, their economic function is such that they constitute a region with definite industrial individuality. It is with this last characteristic that this paper is concerned.

This industrial individuality is characterized by certain qualities which are not common to other sections of Ohio or to the State as a whole. These qualities may be expressed as: The value of the annual product per worker is low; the value added by the manufacturing process is high; the cost of raw materials with respect to product value is low; the primary horsepower per worker is low.

The dominant industry is the manufacture of industrial machinery, in several phases of which these Valley counties lead the State. It is axiomatic that the manufacture of machinery tends to take place near its market. Among the effects of these industries upon the Miami Valley has been to give this machine-making and machine-using area an individuality best characterized by "precision." The influence of no other industry is so potent in giving this region an individuality recognized by a trade.

If, as has been asserted, the industrial ideal is regional equilibrium among the workers in the extractive, manufacturing and commercial fields, the Miami Valley approaches this more nearly than any other section of the state.

43. *Summer Rainfall of 1930: A Relative Representation.*—By R. B. FROST, Oberlin College, Oberlin, Ohio.

There are two principal features of the rainfall of 1930 which characterize it as the most unusual in the history of the weather service. The below normal rainfall which occurred, generally, in the eastern and central portions of the United States, and the above normal rainfall generally peripheral to the dry regions.

Although much has been written and said about the so-called "Drought of 1930," authorities are not agreed as to just what constitutes a drought. However all are in general agreement that any criteria for determining a drought should include: (1) the deficiency of rainfall, with its many ramifications, and (2) its effects upon living things.

Monthly rainfall maps for the four months of summer show that there was a gradual advance and intensity of the below normal rainfall condition at the same time there were record-breaking and near record-breaking downpours occurring elsewhere in the United States. The northern path of the summer cyclones and the intensive development and extension of the Azores high pressure over the southern states had much to do with the increasing intensity of the droughty conditions.

44. *Geology of the Vicinity of Ticonderoga, New York.*—By A. C. SWINNERTON, Antioch College, Yellow Springs, Ohio.

The geologic section near Ticonderoga extends from the Grenville series to the Upper Trenton shale with Potsdam overlying the Pre-cambrian-Paleozoic unconformity. Faulted structures are common in the region and can be grouped in three zones. The easternmost belongs in the Green Mountain system of over-thrusts. The westernmost is the boundary fault of the Adirondack massif. The central zone is complexly imbricated and lies in the general position of Lake Champlain. The structural arrangement outlined by the western and the central fault zones is that of blocks which are uplifted toward the south and south-east and dip gently toward the north and north-west. A brief examination of the literature indicates that this structural type is to be found some distance to the north and also to the south and south-west. The conclusion is suggested that block-faulting of this character may be a significant tectonic feature of the Adirondacks.

45. *The Hypsometric Map versus the Projected Profile Method in Depicting and Determining Erosion Surfaces.*—By KARL VER STEEG, College of Wooster, Wooster, Ohio.

In the past, two methods have been used to detemine erosion levels, the hypsometric and profile methods. In the hypsometric plan the erosion surfaces are determined by coloring in, on a topographic map, all the points at a definite elevation or approximately that. The disadvantages of using the hypsometric method are many A peneplane or erosion surface is not a level one, but rolling, rising toward the divides and descending toward the streams and their outlets. To attempt to color in such a surface seems impossible. The danger lies in getting too many peneplanes. Furthermore, it is very difficult, if not impossible, to picture in one's mind's eye the topography as colored in on a series of contour maps. When such a map is completed it is too large to be published and when reduced to a size suitable for publication, much of the detail must be eliminated.

The major disadvantage of the projected profile is that some of the lower points are concealed by the higher areas. But this can be eliminated to a large degree by using a smaller interval. Projected profiles can be photographed, giving perspective, the effect of depth as well as height and breadth. On the whole, the regular projected profile method, in the opinion of the writer, is superior to any yet devised to depict erosion surfaces.

D. THE SECTION OF MEDICAL SCIENCES.

DR. CHARLES G. ROGERS, Oberlin College, Oberlin, Ohio,
Vice-President.

46. *Some Variations in Muscular Efficiency.*—By W. C. MCNELLY, Miami University, Oxford, Ohio.

In order to determine some factors which influence muscular efficiency, it seemed desirable to determine the amount of variation which could be expected to occur within the individual from time to time.

In the study, a series of tests was used in each of three male subjects during June and July, 1930, using a bicycle ergometer of Prony brake type; two Collins chain compensated gasometers for collecting air; one 600 liter capacity, and one 100 liter capacity; three Haldane gas analysis apparatus, Boothby modification, for analysis of air.

The subjects came to the laboratory in a basal condition and rested for one half hour before mounting the bicycle. After a short rest period on the bicycle, the exhaled air was collected for 10 minutes, measured and sampled. The subject then rode the bicycle for a like period during which the exhaled air was collected, measured and sampled. Over two recovery periods of 6 and 10 minutes respectively the exhaled air was collected and measured and sampled. Later the samples were analyzed and the metabolism over and above that required in sitting on the ergometer was calculated. The work done was determined for each test. The efficiency was then computed.

Subject	Tests	Mean Work	Mean Efficiency	Standard Deviation of Efficiency
S. H	11	10 44 Cal.	22 11%	1 504
MN	5	9 84	21 80	1 050
McN.	5	9 74	22 4	1 47

47. *Oxygen Pulse Under Hypnosis.* By B. M. Davis, Miami University Oxford, Ohio.

Report of experiments preliminary to a study on influence of actual as compared with suggested stimuli in an hypnotic subject. Subject was trained to use Benedict-Roth metabolism apparatus under hypnosis. Variations from normal rate of metabolism were determined: First, while subject was resting normally; second, after an interval of about ten minutes in hypnotic state. Several trials were taken to find variations in metabolic rate which should be considered in subsequent experiments.

48. *Health Habits of University Women.*—By Mrs. Norma Selbert, College of Medicine, Ohio State University, Columbus, Ohio.

In 1928 the writer reported problems and facts which were revealed through a study made with a graduate student, Miss Gladys Grim, and 284 women students in the Ohio State University. Questionnaires, personal conferences, and visits to homes were made. The following questions and answers indicate some of the health problems which concerned investigators and students in 1928.

Question	*Affirmative*	*Negative*
Do you sleep 8 or more hours out of 24?	75	209
Do you take tea oftener than once a day?	274	10
Do you take coffee oftener than once a day?	194	90
Do you play out of doors daily?	90	194
Do you drink a pint of milk each day?	20	264
Do you eat a fruit or green vegetable each meal?	80	204
Do you drink four or more glasses of water each day?	75	209
Do you have a bowel movement every morning?	124	160

The habit of going beyond the fatigue point is the worst vice of 284 women students in the Ohio State University.

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[*] During the past three years the writer has directed investigations which concerned those women who were not practicing the "Rules of the Health Game." With assistance from two graduate nurses, Miss Helen Kienzle and Mrs. Dorothy Stillwell, and help from the Student Health Service, the Dean of Women's Campus Committee, the Psychology Department, and the President's Temporary Personnel Council, several noteworthy improvements were made.

Forty underweight women did not take a pint of milk a day.; 99 did not eat three meals daily; 33 complained of "faulty illimination"; "unhealthful ventilation"; "noise"; "lack of adequate toilet and bathing facilities in the homes in which they reside."

Students were taught how to change unhealthful habits; and how to improve sanitation in their homes.

The habit of going beyond the fatigue point is one of women's worst vices. Almost all of the students who admitted that they had deficient sleep showed obvious effects of fatigue such as: low resistance to disease, and lack of skill in activities which require precise movements and concentration. Their output is irregular, and their work is below the production of classmates who are not fatigued. The majority in this group use coffee or tea more than once a day, indulge in coco-cola, and smoke cigarettes. Thirty complained of insomnia. They attributed their inability to sleep to various causes: "troublesome room-mate," "radio in house"; "worries," and "noise."

Some form of milk is necessary for growth. It is a source of calcium, and at least one pint of milk should be taken daily unless the individual has an idiosyncrasy which makes the use of milk inadvisable. It is therefore noteworthy that 64 of the 264 women who did not take a pint of milk daily "deliberately avoided milk"; "causes billiousness," and gave other emperical theories. Forty of these women are under normal weight and show evidences of calcium deficiency. Moreover, they are "always cold," and "prefer to stay indoors on cool days."

The beginning of adolescence marks the increase in the tuberculosis death rate. It is nearly twice as high among girls as among boys. The girls desire to "stay thin," error in diet, and the fashion of wearing insufficient clothing contribute to the tuberculosis rate. Twenty women who thought they "could not tolerate milk" were taught to sip it, and to eat it with a spoon instead of drinking it. They were also encouraged to take orange juice and raw celery with milk. They then had no digestive disorders whatsoever.

Many students do not take three meals daily. Ninety-nine out of 284 "omit breakfast"; 50 of these "don't want breakfast"; 37 women take "only coffee and a bun, or toast, or a doughnut, for breakfast." They said they "did not have time for more." The majority ate: "meat, potatoes and gravy and pie" for dinner.

Nutrition Specialists in the University Department of Home Economics advise as follows: *Food deemed essential as a part of the daily diet include:* 1 quart (at least 1 pint) milk; 1 egg; 1 raw vegetable such as lettuce, cabbage, or celery; 1 citrus fruit or tomato; 1 raw or uncooked green vegetable; 2 slices of whole wheat or graham bread, or 1½ ounces of whole grain cereal. Add one helping of lean meat, potato, and three servings of butter. More fruit and vegetables may be taken. *It is important to drink water between meals.*

One hundred and one women said they "did not want water," eleven complained because cool water is not available in rooming houses. Sixteen students who drank "little or no water" suffered from constipation; coated tongue or "muddy" complexion.

A great deal has been done lately to make the teaching of Hygiene more practical. Teachers and homemakers are more and more concerned with conditions under which individuals must live; and students are now being taught how to change undesirable habits. Students are taught the *features of an Ideal Home.* The sanitation in 23 homes has been improved. The outstanding items of an ideality may be summarized as follows:

No weeds or rubbish are in the yard about the house. Swings, benches, and chairs in the yard or on the porch lure occupants of the house to stay out of doors. The pavement is clean, and is not in need of repairs. A scraper outside of the door encourages occupants and callers to scrape mud from shoes before entering. A mat (of non-absorbent material) on the porch or in the vestibule, affords a place to stand while rubbers and goloshes are removed prior to entering. No one should be obliged to take wet umbrellas, galoshes, rubbers, or slickers into the bedroom. Arrange a place for these near the entrance. If such cannot be arranged, hang wet garments in the hall outside the owner's room door.

The ideal home is screened and is free from odors, has adequate illumination, healthful ventilation, sufficient hot and cold water, prompt disposal of waste, hygienic beds, comfortable chairs, individual desks for writing, tables, and regular quiet hours. These features are now investigated while considering homes for the "approved list" of homes which is endorsed by university authorities.

Adequate illumination means having sufficient light (without glare) to see quickly and adequately. Measured with a meter, desirable illumination on desk tops would register 10–20 foot-candles; 25 or more foot-candles for sewing on dark materials. The source of illumination should always be above the eyes.

Healthful ventilation. Have radiators below the windows so that cold air will be warmed as it enters. Set up deflectors (boards or thick glass) placed at a slant on the inner edge of the window sill. Have a thermometer in each room, and aim to keep the temperature at 68° F.

Regimes in the ideal home encourage each person to begin every day prepared to carry on happily. (Individuals who do not awaken regularly and gladly need to go to bed earlier). Schedules in the bathroom, and dining room should give everyone the opportunity to wash, dress, eat breakfast, and empty the lower bowel before leaving home.

The idea that training of a scientific sort is necessary for health and homemaking is taking hold at present. It makes for the type of intelligence which tends to decrease hazards and contribute to greater happiness.

49. *Basal Metabolism of College Students.*—By C. G. Rogers and Robert L. Kroc, Oberlin College, Oberlin, Ohio.

This paper reports the results of a series of some 222 basal metabolism tests made upon a group of college students, both male and female, and the relation of the basal metabolism rate to the following:

1. Average basal pulse rate.
2. Average basal respiratory rate.
3. Average basal tidal error.
4. College academic average.
5. High school academic average.
6. Strength rating.
7. Percentile intelligence quotient.
8. Values obtained by other workers.

The results of the work appear to justify the following conclusions:

1. The average basal metabolic rate of the men tested was —4.23% below the Aub-DuBois standards and this conforms in general with the results of other investigators on men students between the ages of 17 and 25.

2. The average basal metabolic rate of the women tested was —4.54%. This is only slightly below the value obtained on the men and is about three per cent higher than the averages reported by most other investigators.

3. The average basal respiratory rate of the men was 11.9 per minute and of the women 10.3.

4. The average basal pulse of the men was 58.8 per minute and of the women 67.2.

5. The average basal tidal air was 511 c c. for the men and 449 c.c. for the women.

6. In general the data on the women tends to support rather than oppose the view that persons of high metabolic rate (within normal limits) have high academic records, intelligence quotients, and strength ratings. This generalization is by no means conclusive for the relationship is quite obscure on the basis of the comparatively few data at hand.

7. The men show a tendency to support the above view only in the case of the high school academic rating.

8. A decrease in basal respiratory rate is definitely correlated with increase in basal tidal air for both men and women.

50. *Silicosis in Ohio Industries: A Preliminary Report.*—By B. E. NEISWANDER, M. D., Consultant, Division of Industrial Hygiene, Department of Health, Columbus, Ohio.

In this preliminary report of the study of silicosis in Ohio industries 30 cases were discussed and the X-Ray films of 10 representative cases were shown. Nine of the 30 cases were sandblasters, only 1 of which had an exposure longer than 7 years; 7 were granite and marble cutters, 6 of which averaged 26 years of occupational life (1 exposure was entire work life); the remaining 14 cases represented 11 various industries. Tuberculosis was a common complicating disease in this series of cases, being present in 15 of the 30 cases studied. It was concluded that the industries of Ohio have not afforded these silicosis victims the protection that should be theirs nor has the State provided legislation as yet to protect them, with or without complications.

51. *The Status of Dental Hygiene.*—By Lonzo G. Bean

The past ten years has witnessed the development of many dental health programs. The more outstanding programs have been summarized in the following pages:

Since January, 1931, the Chicago Department of Health employs eighteen dentists. Fourteen of these men give dental service in fourteen school clinics to children in kindergarten and the first four grades who are unable to pay for private dental care. Four men are employed as dental examiners who examine the mouths of as many children as they can reach in the kindergarten and first four grades.

The Board of Education employs three dentists and five dental hygienists. They are employed as teachers of oral hygiene. Their duties consist of making routine dental examinations and giving mouth hygiene instruction. All of these dentists and hygienists are employed on a full-time basis from 9:00 A. M. until 3:30 P. M., five days a week.

In addition to this service, the Chicago Municipal Tuberculosis Sanatorium employs nine dentists on a part-time basis. Their hours are from 9:00 A. M. until 1:00 P. M. These men perform dental operations for children having or suspected of having tuberculosis.

The Cook County Children's Dental Dispensary, (located at the Cook County Hospital), also employs eight dentists on a full-time basis, who give dental operative service to the poor children of the County.

The Oral Hygiene Committee of the Cincinnati Dental Society worked incessantly during 1900–1910 and until 1916 when this committee became the Free Dental Clinic Society of Cincinnati.

This Society had for its objective the establishment and maintenance of free dental cases, but at the present time, the attention of the public has been turned more to Dental Health Education. This organization placed dental health in and around Cincinnati on a firm foundation and also did much to arouse interest among the members of the Ohio State Dental Society. In 1925 the name was changed to Public Dental Service Society.

During the period from 1911 to 1925, clinics were held and much oral hygiene work was done. At present, the work is financed by the Board of Education and the Community Chest. ($33,450.00 supplied by the former and $10,000.00 by the latter.) There is an advisory committee from the Cincinnati Dental Society that oversees the work in a general way. The work is done by five full-time corrective clinics, one of which is a part-pay clinic, four half-time clinics, one of the four examining and another working for the indigent who are obtaining work certificates. Three floating Prophylaxis Clinics examine.

These clinics are operated by a Supervisor, three full-time dentists, eight part-time dentists, six full-time dental hygienists, a full-time Chief Dental Clinic Assistant, nine full-time dental assistants, one part-time assistant, one part-time clerk and one full-time typist. The Superintendent of Schools is in hearty accord with the program and work that has been done. Under this regime, dental conditions are reported as having improved more than 10% in a period of three years.

Illinois—The aim of the Mouth Hygiene Program of Illinois is to do educational work among school children, parents, and dentists; and the Illinois State Dental Society has a Mouth Hygiene and Public Instruction Committee of about 500 men who have volunteered to aid in carrying out this educational program.

Dr. W. F. Whalen of Peoria, chairman of this committee, has divided the state into districts and appointed district lieutenants and they appoint the dentists of the county as minute men to carry on the program in the county.

In addition to the work as outlined by the State Dental Society, these workers lecture to various lay organizations and to any school system to which they may be invited. Every president of Federated Women's Clubs, and P. T. A. Associations as well as every county superintendent of schools has been asked to assist in this program. Communities have put on a mouth hygiene survey and attempted to have necessary reparative work done but this has not been wholly successful but is rapidly becoming successful through the education of the laity. Several counties, ably assisted by the dental profession, have made mouth surveys and are stressing diet, dental attention, and cleanliness to the school children; prenatal care, diet, and proper dental attention to parents.

At present Illinois is compiling an outline for mouth hygiene education for the first six grades whose aim is to give instruction to teachers for presenting the work.

Iowa—In Iowa, also, the dental health program is largely educational in its work and is carried on through teachers, nurses, dental hygienists, parent-teacher associations and farm bureaus, for the benefit of all grade school children and in some cases is extended to high schools.

No school clinics are held; but table clinics on child dentistry are given for dentists; and schools are held to give nurses instruction in the fundamentals of dentistry. Talks on dental subjects are given at teachers' institutes; and conferences are held with county and city superintendents to persuade them to establish a dental hygiene program in their schools.

These methods have been very successful as the program is now active in the rural schools of 68 of the 99 counties and in the grades of 382 towns and city school systems. However, only 15 of the 68 counties have full-time county nurses and six part-time and only about 50 or 60 towns and cities have full or part-time nursing service, so the work is largely under the direction of the superintendent of schools.

In 1929–1930 they used approximately 500,000 pieces of literature, with many motion picture films and lantern slides. The Sells Health-O-Circus equipment was on the road continuously, carrying lessons in health to thousands of children.

During 1930–1931 the Bureau of Dental Hygiene has extended the work into many new communities—150 towns, cities and consolidated schools and the rural schools of twenty counties.

Sets of lantern slides presenting lessons of dental hygiene are being prepared for grade and high school pupils. The final reports for 1929–1930 revealed that there were 235 towns with an enrollment of 80,213 pupils who were active in the program; and 41 counties with enrollment of 65,911 pupils. 152 towns with an enrollment of 62,318 pupils reported, 32,732 children with returned certificates from their family dentists, and 37 counties with an enrollment of 51,543 reported 16,266 children who did likewise. Four towns were reported as being 100% in dental health. Two other towns would have been 100% but for one or two pupils; and 227 rural schools were awarded 100% certificates.

These figures do not show the actual number of pupils who received full dental corrections, nor the hundreds who received partial work, as some teachers failed to submit reports. Neither can figures adequately represent the benefits derived from dental health education. Results, however, were very gratifying and splendid ground work has been laid for further developments

Michigan—In Michigan, also, we find the work of the Bureau of Dental Hygiene under the Department of Health is entirely educational because they have no funds for clinic work. So far the efforts of the Bureau have been directed toward nurses, parents and dentists by means of lectures, demonstrations, consultations and educational material.

Since the Chief of the Bureau has no assistant and only a part-time secretary, the work has been done through agencies such as Mothers' Clubs, P. T. A. groups and local dentists; and quite gratifying results have been obtained especially through the nurses and school teachers.

The aim has been to provide suitable educational material and plans simple enough for the country school or rural community, yet which can be enlarged to fit the needs of the larger and better organized communities. The Director spends approximately three-fourths of his time supplementing this by lectures, demonstrations, conferences etc., and has found it to be very profitable.

For the past three years special dental instruction has been given in Normal Schools throughout the State, and the results obtained by the teachers who have had this training has been surprisingly satisfactory. When funds will permit it is planned to extend this service to the nurses' training schools, industrial institutions, etc.

Last year 106,137 pieces of literature were distributed and plans are under way to revise and add to this educational material. It is not easy to give evaluation of actual results from educational and advisory work, but reports are very encouraging.

The Children's Fund of Michigan—Fortunately for the children of Michigan, another source of relief has come in the form of the Children's Fund of Michigan, which was established by Senator James Couzens in April, 1929, with a gift of ten million dollars to be expended within 25 years for the welfare of the children of Michigan and elsewhere in the world.

Naturally some of this is spent for dental hygiene work and is under a Director of the Dental Division of the Fund. The Chief of the Bureau of Dental Hygiene of the City of Detroit Health Department is a member of the Dental Advisory Committee of the Children's Fund of Michigan, and in close touch and absolute harmony with the program that has been inaugurated.

The first dentist was employed on November 25, 1929. From that date until the present time, March 23, 1931, the so-called Regular Field Dental Staff was augmented from month to month until it now numbers 22 dentists and 4 oral hygienists, operating in 33 counties and 2 urban areas. (Both dentists and hygienists are employed on a full-time basis. These people are given complete dental units and equipment supplies are furnished without charge to the counties.

Before this help is given there are certain requirements that must be met by the counties as follows: First, the county must provide a nurse; second, the county must provide suitable operating quarters for the dentist, and form a Dental Advisory Committee which shall formally ask for this aid and then advise with the dentist who may be sent.

At present the work does not include X-ray and orthodontic service, although the Fund pays local dentists for X-ray work. The aim is eventually to examine and record mouth conditions of every child in the county and give prophylactic treatment. Notices are sent to parents of children who need corrective treatment, and if parents are financially unable to pay for this, all work necessary to put the child's mouth in 100 percent condition from a health standpoint will be done free of charge in the dental clinics.

It is expected that five years of such work will have proved its economic value and the counties will then take over the program.

Pennsylvania—The Dental Division of the Pennsylvania Department of Health has as its fundamental objective the spreading of propaganda to interest local school districts in the establishment of educational preventive dental health work by means of the dental hygienist. This is done by demonstrations and addresses given before School Boards, Service Clubs and other Civic groups.

The Division does no practical work in any particular community. But in addition to the propaganda before mentioned they have a Supervising Dental Hygienist who spends almost her entire time visiting approximately 150 dental hygienists engaged in school work in the state. One hygienist is able to care for about 1,500 children.

Shorewood—During the past year (May 1, 1929–April 30, 1930) charted mouth examinations have been made for each child from the first to the sixth grade; 63.1% of the children were found to have defective teeth, ranging in number from one to ten or twelve; and pupils of the third and fourth grades were found to have the highest average of defects per child. Corrections have been most satisfying and it is interesting to note that 73.8% of the mouths inspected now have had all necessary corrections made by the dentist. Three rooms, having 30 or more children in each, have 100% corrections; and 15 rooms have from 90% to 94% of the pupils on the Dental Health Roll.

Mal-occlusion or mal-formation of the dental arch was found in 252 children. Of these, 78 now wear orthodontic appliances and many more will be under treatment as soon as the permanent sets of teeth are fully erupted.

The number of cavities found in first permanent molars was most astonishing, while 63 children had lost one or more of these very valuable teeth. Prophylactic treatments were given to 590 children. This half-hour of individual attention gave opportunity for the dental hygienist to get the co-operation of the child in the care of his mouth. Last year 1,492 children were given dental examinations; 480 corrections were made; 900 were referred to a dentist; 1,105 had defective first permanent molars; and 94 had had first permanent molars extracted by a dentist.

Plans for the current year include a Dental Health Exhibit as a project in health education. Pupils will build the exhibit and when parents are invited to visit it, the pupils will give talks on the different phases of Mouth Hygiene and Dental Health Service.

Territory of Hawaii—Hawaii has developed a most interesting and effective plan whereby a staff of 25 dental hygienists together with a supervisor do both prophylactic and educational work, and are classed as special teachers. There are also clinics conducted by dentists, which are unique in that they are most effectively conducted although necessarily decentralized.

There are 189 schools and all but 4 of them were provided with dental service in 1930. In fact the total number of pupils who failed to receive dental education and care were less than 100, and their isolated situation is the only reason they did not have it.

So complete and effective is the program carried on under the Division of Dental Hygiene in Hawaii that it places the territory in advance of most of the States of the Union in this "most important subject."

A few of the cardinal results from dental clinics are:

1. Better physical fitness.
2. Fewer failures in schools.
3. Less years to complete school work.
4. Sending forth a child more physically fit, mentally alert and morally right.
5. Hence, a better citizen.

52. *The Blood Pressure of an Opossum.*—By H. E. Hamlin, Ohio State University, Columbus, Ohio.

While under ether-urethane anaesthesia, the mean carotid blood pressure of a female opossum was measured directly by the use of a standard mercuric sphygmomanometer on January 31, 1931. This animal had been caught in November, 1930, and kept in the laboratory to the date of this experiment. It was interesting to find that its carotid pressure compares favorably with that of other mammals, the normal pressure varying between 102 and 105 mm. Hg. This, however, rose to 130 mm. Hg. after section of the vagi. The normal pulse rate varied between 192 to 198 beats per minute, but was increased to 216 after cutting the vagi. Adrenalin, sensory stimulation, stimulation of the peripheral ends of the divided vagi, asphyxia, gave results similar to those obtained from other mammals under the same conditions.

53. *Further Studies on Gastric Ulcer.*—By SHIRO TASHIRO AND LEON H. SCHMIDT, The Department of Biochemistry, University of Cincinnati, Cincinnati, Ohio.

Based on the following facts brought out in our laboratory during the last few years through investigation of experimental gastric ulcer, we have proposed a theory that the human gastric ulcer is the result of faulty phospholipid metabolism: (1) Tsuruta found that phospholipids antagonize the bile salts in the production of gastric ulcer in the guinea pig and that such physiological conditions as sex and seasonal variation in which phospholipid metabolism is altered also change susceptibility to bile salt. (2) We showed that an experimental condition that produces a change in phospholipid metabolism, such as hyperthyroidism, makes the animal more susceptible to the bile salts. (3) We also showed that most agencies known to produce experimental gastric ulcer cause profound changes in the blood phospholipids.

Whether this decreased phospholipid per se is responsible for the ulcer, or whether the bile salts become more toxic because of the decrease of this antagonizer is yet to be determined.

54. *Sex-Character Education Through Pets.*—By WILLIAM G. VINAL, School of Education, Western Reserve University, Cleveland, Ohio.

(An experiment with children at the Nature Guide
School of Western Reserve University.)

Abraham Lincoln had a distinct educational advantage. For half of his life he lived in a log cabin and twenty-two of these years on a farm. His course of study consisted of the three R's, for about eight weeks in the winter. From the age of seven to eleven he had no formal schooling. His major work, therefore, was extra-curricular.

His Botany was mostly research. He wielded a crude but effective weapon, with which he became acquainted with approximately thirty species of trees that grew on the Indiana Lincoln farm.

He had a semester of Zoology. That, too, was of the extra-curricular variety. He knew the wild mammals of the forest together with the wild turkey and passenger pigeon. His experiences differed from the present laboratory courses in that he had to match wits with the hog, horse, and ox. In comparative anatomy the liver and "lights" were a reality. For preservative he used brine instead of formaldehyde. It may not be amiss to emphasize that each activity was research with a purpose.

His arts and crafts had to do with tools and home-made furniture. He learned swimming in the deep holes of Knob Creek, Larue County, Kentucky. At nineteen he was qualified for "the crew," when he had succeeded in taking a flat-boat down the Ohio and Mississippi to New Orleans. His graduate work in social science, surveying, and law was studied while a storekeeper at New Salem, Illinois.

Lincoln's education was effective, yet few of us would dare to send our children to his school. Since his day homestead industries have been moved to the factory. Cows, pigs, and horses are equally a closed book. The city has taken away the "chores," the great educating power of the past, and placed the child on pavements and alleys. It is during this extra-curricular period of five hours a day that the child gets his real character. Whether this leisure time becomes an asset or liability is important. It is plainly the duty of the city to give back to the child the things that the city has taken away from him.

This paper can deal with but one item of this intricate problem. What do we find in our modern society that is taking the place of the animal education of the farm? Does one anemic gold fish in a glass jar take the place of breaking in the colt? Does a duck baking a loaf of bread for the hen and going wee wee all the way home give the same mental stimulus as the hatching of a chick? Is dusting the erasers and emptying the waste paper basket a substitute for "chores"? It is like asking if there is any substitute for sunshine, or fresh air, or flowers, or grass, or birds? Have not you as scientists been guilty of being so engrossed in your work that you have not questioned what has been given your children? By the very nature of your profession you will agree that there is no substitute for biology. Any failure on your part to demand that your children experience the fundamentals of life will be disastrous. This is one of the most significant and important problems that biologists face today.

One of the experiments at the Nature Guide School of Western Reserve University has been the Pet House. It is my purpose to give a brief summary of the activities at the pet house with the aid of lantern slides. The animal house is located on a lake which gives it many self-evident advantages. Each morning 16 girls, under leadership, do the "chores." The newspapers on the zinc trays are rolled up and fresh ones put in their place. The animals are given water, correct food, and exercise. If young have been born, they are given proper attention. All of this furnishes a basis for wholesome work, joyful play and interesting conversation.

Take the woodchucks for instance. When young they are given a nursing bottle. I do not know of a prettier picture than a group of young girls watching a groundhog nursing. For his vitamines he may indulge in clover instead of lettuce. In this picture they might be called "pals," as both animals are eating at one time from the same carrot. It so happens that what is good for baby woodchucks is good for young humans. One little girl asked her mother if she could have carrots for the rabbit. Her mother said: "I cannot afford to buy carrots for the rabbit, but if you will eat the carrots you may have the peelings for the rabbit." This little girl became the champion carrot eater of Cuyahoga County. The carry-over of food habits is astonishing. Many a child will unconsciously get the point through animal study and will resist the same knowledge through preachment. To hobnob with a woodchuck over a long period of time is instructive adventure. Eventually the woodchuck begins to store up for hibernation. His care-taker is continually building up right health and food attitudes.

Each animal makes its particular contribution. The American Bittern is carnivorous instead of a vegetarian. To catch 14 frogs for a bittern's breakfast is a responsibility. The horned toads were fed by means of a baited fly trap. Conversation about handling the pregnant mother rat, the birth of the young, the suckling of the young, the mammary glands, the milk, was natural, wholesome and truthful. It would not be necessary to mention this if there had not been so much false modesty and untruthfulness in the past.

Another attitude that develops is a regard for scientific accuracy. The children learn that truth is stranger than fiction. Each day an egg is opened to show the development of the chick. This 3-weeks miracle is more wonderful than the story of evolution itself. It will be noted that it is not necessary to put a beaver hat on the chickens to get interest, nor does the mother hen wear a thinking cap nor does the half-chick go to see the queen. The modern princess sits right down with the chickens and partakes of the great lessons of life.

Somewhere along our educational pathway the child is sure to learn about gruff bears eating little folks, about toads and warts, certain classical lies about snakes and the other thousand-and-one myths of Aesop. That this mis-information is learned early is seen in our children, but that it is a mental hazard is also realized as one works with them.

Humaneness is another by-product of the pet house. The command, "Be Kind" is probably not mentioned any more than the phrase "we are studying sex." Attitudes are a result of habits. It does not occur to anyone to tie a tin can to the rat's tail, nor to twist the tail of the 'possum, any more than it does to ask who brought the baby rabbits or if they came from Easter eggs. Unconsciously the children are obeying the same laws of humanity in taking care of squirrels and hawks that are called for between nations.

The pet work is not without a mental challenge. Take the bringing up of a calf, for instance. It takes brains to educate a calf for human control. One must know how to guide him during his playful moods. There is a definite way of teaching him to drink milk when weaning him. To become a useful cow the calf has to be taught certain things. As a matter of fact the calf is teaching the child. Receiving a degree is not necessarily an indication that one is properly trained to rear a calf.

The bringing up of an animal may include all the important phases of education. Take Mordecai Jones selling vegetables with his goat cart and Shepherd dog. Try to short-change him and you will gain respect for his arithmetic. Throw a stone at his dog and you will get an indication of his humaneness. Take hold of his arm and you will know that he has not had soft-pillow bringing up. Invite him to idle his way and learn that he knows the necessity of self-management. Give him an order for future delivery and you will learn of his responsibility. Be helpful and sympathetic and learn how habits and character can be acquired through vital processes. Such are the gifts that come from a study of animals—their nutrition, habits, parenthood, and control.

E. THE SECTION OF PSYCHOLOGY.

DR. JAMES P. PORTER, Ohio University, Athens, Ohio,
Vice-President.

55 *Preliminary Report on A New Diagnostic Technique for Studying Social and Emotional Adjustment.*—By O. A. OHMANN, Cleveland College of Western Reserve University, Cleveland, Ohio.

The test consists of descriptions of 28 typical face-to-face social situations, selected on the basis of frequency of mention by groups of college students. For each of these problem situations a number of possible responses are listed. Among these will generally be found five types of maladjusting behaviors and two types of healthful responses.

The subject is asked to indicate for each of the possible behaviors listed, whether he uses it frequently, occasionally, rarely, or never.

The individual's total score on each of the seven types of social behavior is translated into standard deviation units, from which a diagnostic profile may be constructed. By summing an individual's deviation scores on each of these types of behavior a single total deviation score, or "social adjustment index" may be obtained.

F. THE SECTION OF PHYSICAL SCIENCES.

DR. L. W. TAYLOR, Oberlin College, Oberlin, Ohio,
Vice-President.

56. *A Determination of the Dielectric Constants and Densities of Brom-Benzene—Hexane Solutions, and the Determination of the Electric Moment of the Brom-Benzene Molecule.*—By LOUIS M. HEIL, Ohio University, Athens, Ohio.

In the determination of the electric moments of molecules by the Debye theory, two methods are used:

1. To measure the total polarization at a single temperature and make use of the electronic polarization as given by optical data.

2. To measure the total polarization at different temperatures. The first method leads to erroneous results for the electric moment if an atomic polarization is present.

In this investigation the second method was used. The dielectric constants and densities of mixtures of Brom-benzene in non-polar hexane were measured from —60° C. to 60° C. for molar concentrations of .04 to .20. These data gave polarizations, that when extrapolated to zero concentration, gave an electric moment for the Brom-benzene molecule of 1.38 10-18 electro-static units. This is in agreement with the behavior of substituted molecules as the electric moment of the substituted molecule decreases with increase in atomic weight of the substituted molecule and since the Chlor-benzene molecule has an electric moment of 1.53 10–18 electro-static units.

ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1930.*

JOHN H. SCHAFFNER.

An unusually large number of additions have been made to the Ohio State Herbarium during the year 1930. Only the most important records are mentioned in this list. The distribution records will, however, all appear in the "Revised Catalog of Ohio Vascular Plants" which is now in preparation and which it is hoped can be published promptly after completion. Among the records included in the present list are a considerable number obtained from the Milo G. Williams Herbarium which is owned by Urbana University and which was put in order last year by Dr. Minnie M. Johnson and Miss Margaret Engelhart to whom special thanks are due for assistance in looking over the herbarium. Milo G. Williams was one of the pioneer botanists of Ohio and apparently collected plants from 1833 to 1878. The herbarium also contains specimens from Wm. S. Sullivant, Thos. G. Lea, and other early Ohio botanists.

1. *Ophioglossum vulgatum* L. Adder-tongue. Greendale, Hocking Co., E. A. Albaugh and Len. Stephenson. Washington Twp., Pickaway Co., Leslie L. Pontius and Floyd Bartley.

19. *Anchistea virginica* (L.) Presl. Virginia Chain-fern. Shore of White Pond, near Akron, Summit Co., R. B. Gordon and F. B. Chapman.

25. *Asplenium cryptolepis* Fern. American Wall-rue Spleenwort. Mifflin Twp., Pike Co., Leslie L. Pontius and Floyd Bartley.

49. *Isoetes engelmanni* A. Br. Engelmann's Quillwort. "Ponds," Urbana, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

53.1. *Equisetum kansanum* Schaffn. Kansas Scouring-rush. Springfield Twp., Lucas Co., Louis W. Campbell. Oakshade, Fulton Co., L. E. Hicks.

58. *Lycopodium lucidulum* Mx. Shining Club-moss. "In very wet woods." Bluffton, Allen Co., M'Della Moon. Pine Hollow, between Hemlock and Shawnee, Perry Co., Rodney D. Book.

60. *Lycopodium inundatum* L. Bog Club-moss. A different patch from that reported in 1928. Swanton Twp., Lucas Co., Louis W. Campbell.

62. *Lycopodium obscurum* L. Tree Club-moss. Swanton Twp., Lucas Co., Louis W. Campbell. Near Jackson, Jackson Co., L. Z. Arthur.

63. *Lycopodium complanatum* L. Trailing Club-moss. Springfield, Clark Co., "Damp woods," M. G. Williams. (Urbana Univ. Herb.). Also Mifflin Twp., Pike Co., Leslie L. Pontius and Floyd Bartley.

65. *Selaginella apoda* (L.) Fern. Creeping Selaginella. Franklin Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

72. *Thuja occidentalis* L. Arborvitae. Clear Creek Gorge, Paxton Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

104. *Potamogeton robbinsii* Oakes. Robbin's Pondweed. Indian Lake, Logan Co., Geo. A. Heffner, F. B. Chapman, and R. B. Gordon.

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*Papers from the Department of Botany, The Ohio State University, No. 274.

108. *Brasenia schreberi* Gmel. Water-shield. Urbana, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

132. *Wolffiella floridana* (J. D. Sm.) Thomp. Florida Wolffiella. Buckeye Swamp Sanctuary, Buckeye Lake, Perry Co.; South shore of Buckeye Lake, Fairfield Co., Lawrence E. Hicks.

133. *Wolffia columbiana* Karst. Columbia Wolffia. Buckeye Lake, Thornport, Perry Co.; South shore of Buckeye Lake, Fairfield Co.; New Garden, Columbiana Co.; Attica, Seneca Co.; Wayne Twp., Ashtabula Co.; Old Woman Creek Swamp, Erie Co.; Zoar Fish Hatchery, Tuscarawas Co.; Fredericktown, Knox Co.; Fountain Park, Champaign Co.; Athens, Athens Co.; Milford Center, Union Co.; Edon, Williams Co.; Edgerton, Defiance Co., L. E. Hicks.

134. *Wolffia punctata* Griseb. Punctate Wolffia. Indian Lake, Logan Co.; Cranberry Island, Buckeye Lake, Licking Co.; Zoar, Tuscarawas Co.; Fairport and Lehman, Lake Co.; Trinway, Muskingum Co.; Fireside, Seneca Co.; Milford Center, Union Co.; Buckeye Swamp Sanctuary, Buckeye Lake, Perry Co.; South shore of Buckeye Lake, Fairfield Co., Lawrence E. Hicks.

138. *Cyperus inflexus* Muhl. Awned Cyperus. Wakatomika, Creek, Licking Co., R. B. Gordon.

141. *Cyperus engelmanni* Steud. Engelmann's Cyperus. Indian Lake, Logan Co., Geo. A. Heffner, F. B. Chapman, and R. B. Gordon.

155. *Eleocharis tenuis* (Willd.) Schultes. Slender Spike-rush. Red Hills region near Westerville, Delaware Co., F. B. Chapman.

170.1. *Eriophorum gracile* Koch. Slender Cotton-sedge. In bog at Baumgardner's Pond, Jackson Twp., Franklin Co., R. B. Gordon and E. S. Thomas.

184.1. *Carex texensis* (Torr.) Bail. Texas Sedge. Growing under trees in Goodale Park, Columbus, Franklin Co., John H. Schaffner.

197. *Carex decomposita* Muhl. Large-panicled Sedge. "Very Rare." Columbus, Franklin Co., Wm. S. Sullivant (Williams Herb.). Urbana Univ.

208. *Carex scoparia* Schk. Pointed Broom Sedge. Shawnee State Forest, Scioto Co., Conrad Roth.

247. *Carex hitchcockiana* Dew. Hitchcock's Sedge. Webster Twp., Wood Co., E. L. Moseley.

276. *Carex irregularis* Schw. (C. oederi Retz.). Green Sedge. Cedar Swamp, Champaign Co., 1839. Wm. S. Sullivant. (Williams Herbarium). Urbana Univ.

297. *Bromus kalmii* Gr. Kalm's Chess. Liberty Twp., Highland Co., Katie M. Roads.

321.1. *Uniola latifolia* Mx. Broad-leaf Spike-grass. Rocky Fork Gorge, Highland Co., Leslie L. Pontius, and Floyd Bartley.

344. *Koeleria cristata* (L.) Pers. Crested Koeler-grass. Clifton Gorge, Greene Co., R. B. Gordon.

349. *Phragmites phragmites* (L.) Karst. Common Reed-grass. Loganda, near Springfield, Clark Co., T. G. Lea (Williams Herb.). Urbana Univ.

352. *Arrhenatherum elatius* (L.) Brauv. Oat-grass. Bowling Green, Wood Co., E. L. Moseley.

353. *Trisetum pennsylvanicum* (L.) Beauv. Marsh False-oats. Liberty Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

356. *Avena fatua* L. Wild Oats. Hillsboro, Highland Co., Katie M. Roads.

356.1. *Deschampsia caespitosa* (L.) Beauv. Tufted Hair-grass. Cedar Swamp, Champaign Co., H. Bruce Hill and R. B. Gordon.

368. *Elymus hirsutiglumis* Scribn. & Sm. Strict Wild-rye. Fairport, Lake Co., L. E. Hicks.

376. *Spartina michauxiana* Hitch. Tall Slough-grass. Near Cincinnati, Hamilton Co., T. G. Lea (Williams Herb.). Urbana Univ.

378. *Capriola dactylon* (L.) Ktz. Bermuda-grass. "Spread in a garden on town lot, completely covering it." Pleasantville, Fairfield Co., C. J. Willard.

383. *Sporobolus asper* (Mx.) Kunth. Longleaf Rush-grass. Pickaway Co., Glenn W. Blaydes. Rocky Fork Gorge, Highland Co., Floyd Bartley and Leslie L. Pontius.

396.1. *Alopecurus aristatulus* Mx. Short-awned Foxtail. Swamp near Circleville, Pickaway Co., John H. Schaffner.

409. *Stipa spartea* Trin. Porcupine-grass. Swanton, Fulton Co., L. E. Hicks.

411. *Aristida oligantha* Mx. Few-flowered Triple-awned-grass. Liberty Twp., Ross Co., Floyd Bartley and Leslie L. Pontius

416. *Phalaris canariensis* L. Canary-grass. Columbus, Franklin Co., M. S. and S. S. Humphrey.

454.1. *Echinochloa frumentacea* (Roxb.) Link. Billion-dollar-grass. Freight Yard, Hillsboro, Highland Co., Katie M. Roads.

478. *Lilium umbellatum* Pursh. Western Red Lily. Holland, Lucas Co., L. E. Hicks.

481.2. *Nothoscordum bivalve* (L.) Britt. Yellow False-garlic. Urbana, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

494. *Melanthium virginicum* L. Virginia Bunch-flower. "Wet Meadows." Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

497. *Anticlea elegans* (Pursh) Rydb. Glaucous Anticelea. Yellow Springs, Greene Co., M. G. Williams (Urbana Univ. Herb.).

500. *Triantha glutinosa* (Mx.) Baker. Glutinous Triantha. Springfield, Clark Co. and Urbana, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

530. *Tradescantia reflexa* Raf. Reflexed Spiderwort Agosta, Marion Co., A. E. Waller. Black Hand Gorge, Licking Co., Southwest of Gallipolis, Gallia Co., L. E. Hicks.

546.1. *Juncus brachycarpus* Engelm. Short-fruited Rush. Union Twp., Highland Co., Katie M. Roads.

557. *Iris versicolor* L. Northern Blue-flag. In Tamarack bog, Farmer, Defiance Co., Delta, Fulton Co., Williams Center, Williams Co., L. E. Hicks and Robert McCormick. Also "growing near waters edge near to clumps of *Iris virginica*," Turkeyfoot Point, Indian Lake, Logan Co., L. E. Hicks.

557.3. *Iris foliosa* Mack. and Bush. Leafy Blue-flag. Napoleon, Henry Co.; Essex and Richwood, Union Co.; Greenville, Darke Co., L. E. Hicks and R. H. McCormick. Green Camp Twp., Marion Co., R. H. McCormick.

557.4. *Iris fulva* Ker. Red-brown Iris. "Escaped and naturalized along a brook in a pasture near Mechanicsburg," Champaign Co., A. E. Waller.

558.1. *Iris pumila* L. Dwarf Iris. "Escaped along road 3 miles north of Napoleon, Henry Co., Lawrence E. Hicks.

561.1. *Sisyrinchium mucronatum* Mx. Michaux's Blue-eyed-grass. West of Bainbridge, Ross Co., L. E. Hicks.

580. *Blephariglottis peramoena* (Gr.) Rydb. Fringeless Purple Orchis. Vinton Co., E. A. Albaugh and Len. Stephenson.

581. *Pogonia ophioglossoides* (L.) Ker. Rose Pogonia. Cedar Swamp, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

582. *Isotria verticillata* (Willd.) Raf. Whorled Isotria. Red Hills region, Central College, Franklin Co., F. B. Chapman and R. B Gordon.

587. *Ibidium plantagineum* (Raf.) House. Broadleaf Lady's-tresses. Springfield Twp., Lucas Co., Louis W. Campbell; Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

594. *Malaxis unifolia* Mx. Green Addermouth. Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.); Buchtel, Athens Co., Len. Stephenson and Walter Porter; Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

614a. *Ranunculus repens pleniflorus* Fern. Double-flowered Creeping Buttercup. Wapakoneta, Auglaize Co., Wm. Kayser; "A general escape in Hillsboro, Highland Co., Katie M. Roads.

657.1. *Berberis thunbergii* D. C. Japanese Barberry. "In a pasture," Hillsboro, Highland Co., Katie M. Roads.

663. *Drosera rotundifolia* L. Roundleaf Sundew. Springfield Twp., Lucas Co., Louis W. Campbell.

669. *Argemone mexicana* L. Mexican Prickly-poppy. Watertown Twp., Washington Co., Frances Raymond.

682. *Berteroa incana* (L.) DC. Hoary Berteroa. "Abundant in Pasture." Metamora, Fulton Co., L. E. Hicks.

701.1. *Lepidium perfoliatum* L. Perfoliate Peppergrass. "Growing on railroad track." Barnesville, Belmont Co., Emma E. Laughlin.

703. *Thlaspi arvense* L. Field Penny-cress. La Rue, Marion Co., L. E. Hicks.

705. *Alliaria alliaria* (L.) Britt. Garlic Mustard. Bucyrus, Crawford Co., R. A. Dobbins.

708. *Cheirinia cheiranthoides* (L.) Link. Worm-seed Mustard. Holgate, Henry Co., C. J. Willard; Harmony, Clark Co., John H. Schaffner.

713. *Norta irio* (L.) Britt. Longleaf Hedge-mustard. Railroad track near Hillsboro, Highland Co., Katie M. Roads.

718. *Barbarea stricta* Andrz. Erect Winter-cress. Peniel, Gallia Co., F. B. Chapman and R. W. Limes.

727. *Arabis virginica* (L.) Trel. Virginia Rock-cress. Red Hills region near Central College, Franklin Co., R. B. Gordon and F. B. Chapman.

733. *Cardamine rotundifolia* Mx. Roundleaf Bitter-cress. Jefferson Twp., Ross Co.; Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

760.1. *Geranium dissectum* L. Cut-leaf Crane's-bill. Angola Road, West of Toledo, Lucas Co., E. L. Moseley.

768. *Oxalis brittoniæ* Small. Britton's Wood-sorrel. Shawnee State Forest, Scioto Co., L. E. Hicks.

769. *Oxalis rufa* Small. Red Wood-sorrel. Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

773.1. *Linum grandiflorum* Desf. Large-flowered Flax. Accidental. From northern Africa. Wapakoneta, Auglaize Co., Wm. Kayser.

800. *Tithymalus obtusatus* (Pursh) Kl. & Garcke. Bluntleaf Spurge. Urbana, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

804. *Tithymalus peplus* (L.) Hill. Petty Spurge.
(1), Urbana, Champaign Co. and (2), Cincinnati, Hamilton Co., M. G. Williams. (Urbana Univ. Herb.); Ada, Hardin Co., R. A. Dobbins.

809. *Chamaesyce rafinesqui* (Greene) Small. Hairy Spurge. Oak openings west of Toledo, Lucas Co., E. L. Moseley.

815. *Callitriche palustris* L. Vernal Water-starwort. Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

827. *Napaea dioica* L. Glade-mallow. Tiverton and Tuscarawas Twps., Coshocton Co., Frank B. Selby; Bellbrook, Greene Co., L. E. Hicks.

830. *Hibiscus militaris* L. Halberd-leaf Rose-mallow. Middletown, Butler Co., M. G. Williams. (Urbana Univ. Herb.).

840. *Hypericum cistifolium* Lam. Round-podded St. John's-wort. Otsego, Maumee River, Wood Co., E. L. Moseley.

850. *Triadenum virginicum* (L.) Raf. Baumgardner's Pond, Jackson Twp., Franklin Co., R. B. Gordon and F. B. Chapman.

866.1. *Viola walteri* House. Walter's Violet. Bainbridge Caves, Highland Co., Lawrence E. Hicks; Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

870. *Viola odorata* L. Sweet Violet. Springfield Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

873. *Viola pallens* (Banks) Brain. Woodland White Violet. Westboro, Clinton Co., E. Lucy Braun; Andover Twp., Ashtabula Co., L. E. Hicks.

874. *Viola lanceolata* L. Lanceleaf Violet. Higby Prairie, Ross Co., L. E. Hicks.

877. *Viola hirsutula* Brain. Southern Wood Violet. Greer, Knox Co., Lawrence E. Hicks.

880. *Viola triloba* Schw. Three-lobed Violet. Bainbridge Caves, Highland Co., Lawrence E. Hicks; Coshocton Co., F. B Selby; Beach City, Sugar Creek Twp., Stark Co., W. H. Camp; "Neotoma," Hocking Co., E. S. Thomas and R. B. Gordon.

884. *Viola sagittata* Ait. Arrowleaf Violet. Higby Prairie, Ross Co.; Delta, Fulton Co., L. E. Hicks.

885. *Viola pedata* L. Birdfoot Violet. Monclova Twp., Lucas Co., L. W. Campbell and M. R. Cleve.

912. *Silene latifolia* (Mill.) Britt. & Rend. Bladder Campion. Circleville Twp., Pickaway Co., Leslie L. Pontius and Floyd Bartley.

914. *Silene rotundifolia* Nutt. Roundleaf Catchfly. Jefferson and Franklin Twps., Ross Co., Floyd Bartley and Leslie L. Pontius.

917. *Silene dichotoma* Ehrh. Forked Catchfly. "Several plants in a pasture lot." Liberty Twp., Highland Co., Katie M. Roads.

918. *Silene conica* L. Striate Catchfly. Swanton Twp., Lucas Co., L. W. Campbell.

919. *Silene regia* Sims. Royal Catchfly. Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

962. *Cycloloma atriplicifolium* (Spreng.) Coult. Tumbleweed. Little Cedar Point, Jerusalem Twp., Lucas Co., L. W. Campbell; Holland, Lucas Co., L. E. Hicks.

965.2. *Atriplex argentea* Nutt. Silvery Orache. In old Cemetery, Woodville, Sandusky Co. From the west. E. L. Moseley.

1017. *Waldsteinia fragarioides* (Mx.) Tratt. Dry Strawberry. Camp Bud, Delaware Co., C. E. O'Neal, L. H. Tiffany and G. W. Blaydes.

1027. *Rubus strigosus* Mx. Wild Red Raspberry. Cedar Swamp, Champaign Co., Glenn W. Blaydes.

1034. *Filipendula rubra* (Hill.) Rob. Queen-of-the-prairie. Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

1034.1. *Filipendula ulmaria* (L.) Maxim. Queen-of-the-meadow. Escaped near Colton, Fulton Co., L. E. Hicks.

1102. *Baptisia australis* (L.) R. Br. Blue Wild-indigo. (1), Dayton, Montgomery Co. and (2), Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

1104. *Baptisia leucantha* T. & G. Large White Wild-indigo. Upper Sandusky, Wyandot Co., L. E. Hicks; South Charleston, Clark Co., R. B. Gordon and F. B. Chapman; Paxton Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

1122. *Lotus corniculatus* L. Bird's-foot Trefoil. Ross Co., Leslie L. Pontius and Floyd Bartley.

1129. *Cracca virginiana* L. Virginia Goat's-rue. (1), Portsmouth, Scioto Co. and (2), Dayton, Montgomery Co , M. G. Williams. (Urbana Univ. Herb.).

1153. *Lespedeza nuttallii* Darl. Nuttall's Bush-clover. Devil's Backbone, Washington Twp., Pickaway Co., Leslie L. Pontius and Floyd Bartley.

1157. *Lespedeza virginica* (L.) Britt. Slender Bush-clover. Liberty Twp., Highland Co., Katie M. Roads; Springfield Twp., Ross Co., Leslie L. Pontius and Floyd Bartley.

1173.2. *Lathyrus tuberosus* L. Tuber-bearing Pea. Escaped. Canfield, Trumbull Co., H. J. Longnecker and C. J. Willard.

1183. *Sedum acre* L. Wall-pepper. Clifton Gorge, Greene Co., Floyd B. Chapman.

1189. *Sullivantia sullivantii* (T. & G.) Britt. Sullivantia. Mifflin Twp., Pike Co., Buckskin Creek Gorge, Paxton Twp., Ross Co., Leslie L. Pontius and Floyd Bartley.

1192.1. *Mitella nuda* L. Naked Bishop's-cap. Cedar Swamp, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

1194. *Ammannia coccinea* Rottb. Longleaf ammannia. Jerusalem Twp., Lucas Co., L. W. Campbell.

1200. *Rhexia virginica* L. Virginia Meadow-beauty. Vinton Co., E. A. Albaugh and Len. Stephenson.

1219. *Euonymus americanus* L. American Strawberry-bush. Urbana, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

1229. *Acer spicatum* Lam. Mountain Maple. Along the Wakatomika, Licking Co., E. N. Transeau, W. H. Camp, and Glenn W. Blaydes.

1257. *Urtica urens* L. Small nettle. Coshocton Co., Frank B. Selby.

1323. *Opuntia opuntia* (L.) Karst. Common Prickly-pear. Southwest of Gallipolis, Gallia Co. "An area of sandy hillside well covered with large clumps." L. E. Hicks.

1326. *Ribes lacustre* (Pers.) Poir. Swamp Current. Clifton Gorge, Greene Co., Leslie L. Pontius, and Floyd Bartley.

1344. *Raimannia laciniata* (Hill.) Rose. Cutleaf Evening-primrose. Coshocton, Coshocton Co., Frank B. Selby.

1345. *Kneiffia pratensis* Small. Meadow Sundrops. Springfield Twp., Lucas Co., L. W. Campbell.

1348. *Hartmannia speciosa* (Nutt.) Small. White Evening-primrose. Washington Court House, Fayette Co., R. B. Gordon and F. B. Chapman.

1370. *Phoradendron flavescens* (Pursh) Nutt. American Mistletoe. Liberty and Colerain Twps., Ross Co. In both places on Nyssa silvatica. Floyd Bartley and Leslie L. Pontius.

1392. *Hypopitys lanuginosa* (Mx.) Nutt. Hairy Pinesap. Fort Amanda, Logan Twp., Auglaize Co., Geo. A. Heffner.

1395. *Azalea lutea* L. Flame Azalea. Liberty Twp., Jackson Co., Leslie L. Pontius and Floyd Bartley.

1397. *Rhododendron maximum* L. Great Rhododendron. Jackson Twp., Jackson Co., Floyd Bartley and Leslie L. Pontius.

1398. *Kalmia latifolia* L. Mountain Kalmia. Northern part of Liberty Twp., Guernsey Co., L. A. Robertson.

1401. *Oxydendrum arboreum* (L.) DC. Sorrel-tree. Portsmouth, Scioto Co., M. G. Williams. (Urbana Univ. Herb.).

1403. *Gaultheria procumbens* L. Creeping Wintergreen. Delta, Fulton Co., Lawrence E. Hicks.

1418. *Phlox ovata* L. Mountain Phlox. Monclova Twp., Lucas Co., L. W. Campbell.

1418a. *Phlox ovata carolina* (L.) Wherry. Carolina Mountain Phlox. Near Hillsboro and in Liberty Twp., Highland Co., Katie M. Roads.

1419. *Phlox glaberrima* L. Smooth Phlox. Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

1420. *Phlox pilosa* L. Downy Phlox. "In woods." Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

1421. *Phlox divaricata* L. Wild Blue Phlox. A pure white-flowered form. In woods, Liberty Twp., Highland Co., Katie M. Roads.

1422. *Phlox stolonifera* Sims. Creeping Phlox. Jackson Co., Dan W. Williams.

1424. *Gilia rubra* (L.) Heller. Standing-cypress. East of old cemetery, Woodville, Sandusky Co., E. L. Moseley.

1428. *Ipomoea lacunosa* L. Small-flowered White Morning-glory. Scioto Twp., Ross Co.; Mifflin Twp., Pike Co., Leslie L. Pontius and Floyd Bartley.

1432. *Convolvulus spithamaeus* L. Upright Bindweed. Coshocton Co., Frank B. Selby; Cantwell Cliffs, Hocking Co., Leslie L Pontius and Floyd Bartley.

1432.1. *Convolvulus fraterniflorus* Mack & Bush. Short-stalked Bindweed. Crawford and Tuscarawas Twps., Coshocton Co., Frank B. Selby.

1433.1. *Convolvulus repens* L. Trailing Bindweed. Jackson Co., R. B. Gordon.

1441. *Cuscuta cephalanthi* Engel. Buttonbush Dodder. Angola, Lucas Co., E. L. Moseley.

1444. *Cuscuta paradoxa* Raf. Glomerate Dodder. Jackson Twp., Pickaway Co., Leslie L. Pontius and Floyd Bartley.

1465. *Gentiana crinita* Froel. Fringed Gentian. Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

1466. *Gentiana puberula* Mx. Downy Gentian. "Brush prairies." Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

1467. *Gentiana saponaria* L. Soapwort Gentian. Higby Prairie, S. E. of Chillicothe, Ross Co., E. N. Transeau.

1474. *Menyanthes trifoliata* L. Buckbean. Baumgardner's Pond, Jackson Twp., Franklin Co., F. B. Chapman and R. B. Gordon.

1478. *Apocynum sibiricum* Jacq. Clasping-leaf Dogbane. Jerusalem Twp., Lucas Co., L. W. Campbell.

1481. *Acerates floridana* (Lam.) Hitchc. Florida Milkweed. Burlingham, Meigs Co., Lawrence E. Hicks.

1484. *Asclepias purpurascens* L. Purple Milkweed. Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

1486. *Asclepias pulchra* Ehrh. Hairy Milkweed. Kossuth, Auglaize Co., L. E. Hicks; Byers Hollow, Eagle Twp., Vinton Co., Floyd Bartley and Leslie L. Pontius.

1488. *Asclepias amplexicaulis* Sm. Bluntleaf Milkweed. Swanton, Fulton Co.; West of Gallipolis, Gallia Co., Lawrence E. Hicks.

1501.1. *Lycium chinene* Mill. Chinese Matrimony-vine. From E. Asia. "Escaped near Andover," Ashtabula Co., Lawrence E. Hicks.

1505. *Physalis virginiana* Mill. Virginia Ground-Cherry. Colerain Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

1552. *Aureolaria pedicularia* (L.) Raf. Fernleaf False Foxglove. Buchtel, Athens Co., Len. Stephenson.

1554. *Aureolaria laevigata* (Raf.) Raf. Entire-leaf False Foxglove. Lick Run near Nelsonville, Athens Co., E. A. Albaugh and Len. Stephenson.

1559. *Agalinis skinneriana* (Wood) Britt. Was by mistake credited to Wood County in the "1929 additions." The record should read Fulton Co.

1561. *Castilleja coccinea* (L.) Spreng. Scarlet Painted-cup. Jefferson Twp., Madison Co., John Wolfe; "Damp fields." Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

1580. *Martynia louisiana* Mill. Unicorn-plant. Spontaneous at Nelsonville, Athens Co., Len. Stephenson.

1585. *Stomoisia cornuta* (Mx.) Raf. Horned Bladderwort. Cedar Swamp, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

1599. *Lithospermum latifolium* Mx. American Gromwell. Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

1604. *Onosmodium hispidissimum* Mack. Shaggy False Gromwell. Buchtel, Athens Co., Len. Stephenson.

1605.1. *Borago officinalis* L. Borage. "Very common and very persistent after cultivation." Hillsboro, Highland Co., Katie M. Roads.

1626. *Scutellaria pilosa* Mx. Hairy Skullcap. Paxton Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

1638. *Clinopodium glabrum* (Nutt.) Ktz. Low Calamint. "Woods." Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

1642.1. *Koellia pycnanthemoides* (Leav.) Ktz. Southern Mountain-Mint. "Very rare." Springfield, Clark Co., about 1833-35. M. G. Williams. (Urbana Univ. Herb.).

1666.1. *Dracocephalum speciosum* Sw. Showy Dragonhead. Washington and Tuscarawas Twps., Coshocton Co., Frank B. Selby; Hocking Co., E. A. Albaugh and Len. Stephenson; Pickaway Twp., Pickaway Co., Floyd Bartley and Leslie L. Pontius.

1668. *Synandra hispidula* (Mx.) Britt. Synandra. Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

1686. *Salvia lyrata* L. Lyreleaf Sage. White's Gulch, Jackson Co., E. A. Albaugh and Len. Stephenson; Byers Hollow, Eagle Twp., Vinton Co. and Jefferson Twp., Ross Co. Floyd Bartley and Leslie L. Pontius.

1687. *Salvia lancifolia* Poir. Lanceleaf Sage. Jackson Twp., Pickaway Co., Leslie L. Pontius and Floyd Bartley.

1698. *Aralia spinosa* L. Angelica-tree. Liberty Twp., Jackson Co., Leslie L. Pontius and Floyd Bartley.

1704. *Eryngium aquaticum* L. Rattlesnake-master. Springfield and between Springfield and Clifton Gorge, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

1718. *Angelica villosa* (Walt.) B. S. P. Hairy Angelica. Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

1719. *Oxypolis rigidus* (L.) Raf. Cowbane. Buchtel, Athens Co., Len. Stephenson.

1730. *Hydrocotyle americana* L. American Marsh-pennywort. Along the Wapatomika, Licking Co., E. N. Transeau and Glenn W. Blaydes.

1733. *Aegopodium podagraria* L. Goutweed. Variegated form. Wapakoneta, Auglaize Co., Wm. Kayser.

1738. *Cicuta bulbifera* L. Bulb-bearing Water-hemlock. Marsh near Cincinnati, Hamilton Co., C. W. Short M. D. (1836). (Williams Herb.). Urbana Univ.

1749. *Cynoxylon canadense* (L.). Dwarf Dogwood. Andover Twp., Ashtabula Co., Lawrence E. Hicks.

1753.1. *Houstonia lanceolata* (Poir.) Britt. Lanceleaf Houstonia. Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

1760. *Diodia teres* Walt. Rough Buttonweed. Mifflin Twp., Pike Co., Leslie L. Pontius and Floyd Bartley.

1780.1. *Galium verum* L. Yellow Bedstraw. In Field, Cantwell Cliffs, Hocking Co., Leslie L. Pontius and Floyd Bartley.

1764. *Galium boreale* L. Northern Bedstraw. Metamora, Fulton Co., L. E. Hicks.

1769. *Galium claytoni* Mx. Clayton's Bedstraw. Baumgardner's Pond, Jackson Twp., Franklin Co., R. B. Gordon and F. B. Chapman.

1776 *Viburnum pubescens* (Ait.) Pursh. Downy Arrow-wood. Clifton Gorge, Greene Co.; Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

1786. *Triosteum angustifolium* L. Yellow Horse-gentian. Carthagena, Mercer Co., Conrad Dueringer.

1797. *Lonicera hirsuta* Eaton. Hairy Honeysuckle Mifflin Twp., Pike Co.; Clifton Gorge, Green Co., Floyd Bartley and Lelie L. Pontius.

1807. *Valeriana pauciflora* Mx. Large-flowered Valerian. Belmont Co., A. J. Pancake.

1809. *Valeriana officinalis* L. Garden Valerian. Nelsonville, Athens Co., Len. Stephenson.

1812. *Campanula rotundifolia* L. Harebell. Abundant in Paxton Twp., Ross Co., Floyd Bartley, and Leslie L. Pontius.

1869. *Bidens frondosa* L. Black Beggar-ticks. Lafayette Twp., Coshocton Co., Frank B. Selby.

1897. *Antennaria solitaria* Rydb. Single-headed Everlasting. Springfield Twp., Ross Co.; Byers Hollow, Eagle Twp., Vinton Co., Floyd Bartley and Leslie L. Pontius.

1901. *Grindelia squarrosa* (Pursh) Dun. Broadleaf Gum-plant. Salt Creek Twp., Hocking Co., Leslie L. Pontius and Floyd Bartley.

1904. *Solidago squarrosa* Muhl. Stout Goldenrod. Salt Creek Twp., Hocking Co., Floyd Bartley and Leslie L. Pontius.

1922. *Solidago rigida* L. Stiff Goldenrod. Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

1924. *Solidago riddellii* Frank. Riddell's Goldenrod. Dayton, Montgomery Co. "Wet meadows." M. G. Williams. (Williams Herb. Urbana Univ.).

1928. *Boltonia asteroides* (L.) L'Her. Boltonia. "Roadside." Buchtel, Athens Co., Len. Stephenson.

1947.1. *Aster concinnus* Willd. Narrowleaf Smooth Aster. Rocky Fork, Highland Co., Floyd Bartley and Leslie L. Pontius.

1948. *Aster junceus* Ait. Rush Aster. Lafayette Twp., Coshocton Co., Frank B. Selby.

1950. *Aster hirsuticaulis* Lindl. Roughstem Aster. Lafayette Twp., Coshocton Co., Frank B. Selby.

1952. *Aster multiflorus* Ait. Dense-flowered Aster. Paxton Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

1979. *Lacinaria squarrosa* (L.) Hill. Scaly Blazing-star. Springfield, Clark Co., and Urbana, Champaign Co., M. G. Williams. (Urbana Univ. Herb.).

1982. *Lacinaria scariosa* (L.) Hill. Large Blazing-star. "Dry prairies." Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

1988. *Elephantopus carolinianus* Willd. Carolina Elephant's-foot. Head of Morgan Creek, Pike Co. and Paxton Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

2001. *Artemisia caudata* Mx. Wild Wormwood. Bay Point, Ottawa Co., L. E. Hicks.

2005. *Artemisia pontica* L. Roman Wormwood. Wapakoneta, Auglaize Co., Wm. Kayser.

2005.1. *Artemisia ludoviciana* Nutt. Western Mugwort. Wapakoneta, Auglaize Co., Wm. Kayser.

2008. *Mesadenia reniformis* (Muhl.) Raf. Great Indian-plantain. Mifflin Twp., Pike Co., Floyd Bartley and Leslie L. Pontius.

2010. *Mesadenia tuberosa* (Nutt.) Britt. Tuberous Indian-plantain. Springfield, Clark Co., M. G. Williams. (Urbana Univ. Herb.).

2014.2. *Senecio plattensis* Nutt. Prairie Squaw-weed. Bowling Green, Wood Co., E. L. Moseley.

2016. *Tussilago farfara* L. Coltsfoot. Milan, Erie Co., Miss Hawley (E. L. Moseley).

2017. *Arctium tomentosum* (Lam.) Schk. Woolly Burdock. Tiverton and Tuscarawas Twps., Coshocton Co., Frank B. Selby.

2029.1. *Centaurea vochinensis* Bernh. Tyrol Star-thistle. Pickaway and Circleville Twps., Pickaway Co., Leslie L. Pontius and Floyd Bartley.

2035. *Hypochaeris radicata* L. Long-rooted Cat's-ear. Buchtel, Athens Co., Len. Stephenson.

2047. *Lactuca villosa* Jacq. Hairy-veined Blue Lettuce. Lafayette Twp., Coshocton Co., Frank B Selby; Wapakoneta, Auglaize Co , Wm. Kayser.

2054. *Nabalus crepidineus* (Mx.) DC. Corymbed Rattlesnake-root Dayton, Montgomery Co., M. G. Williams. (Urbana Univ. Herb.).

2061. *Hieracium greenii* Port. and Britt. Green's Hawkweed. Green Twp., Ross Co., Floyd Bartley and Leslie L. Pontius.

2063. *Hieracium aurantiacum* L. Orange Hawkweed. Buchtel, Athens Co., Len. Stephenson; Spencer Twp., Lucas Co., L. W. Campbell and E. S Thomas.

NOTICE

This number of the OHIO JOURNAL OF SCIENCE contains the Proceedings of the Ohio Academy of Science for the 41st meeting.

Under a plan recently consummated the Journal, which has been the official organ of the Academy since 1904, will be the main avenue of publication for the Academy. It will include the proceedings, membership and officers lists, abstracts of papers presented and so far as practicable the full papers presented at the Academy meetings as well as contributed articles from Academy members and other scientific workers. By agreement with the Ohio State University a joint Administrative Board will manage the Journal, determining policies, naming editorial staff and sharing financial responsibility. The Journal will be sent as exchange for publications of other Academies and scientific organizations which have heretofore received the Proceedings, but organizations that prefer to receive the Proceedings only will kindly notify the Academy secretary so that such exchange may be continued. A limited extra number of the Proceedings will be available for such exchange or for individuals who may desire them in separate form.

As this number goes to press information has been received of the death of the veteran Naturalist, Mr. Chas. Dury of Cincinnati. Mr. Dury was one of the early members of the Ohio Academy of Science and its President in 1907. A more detailed notice of his life may be expected in a later number of the *Journal.*

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THE DEVELOPMENT OF DRAINAGE SYSTEMS AND THE DYNAMIC CYCLE.*

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INTRODUCTION.

The present study looks at streams from the dynamic viewpoint.[1] It goes without saying that the forces at work on the lands of the earth are just as important in physiography as are the results brought about by those forces.

The concept of age, applied to valleys in a geomorphologic sense, has been carried over on occasion and applied to streams in such a way as especially to emphasize change of velocity and its results. A stream is never young, never mature, and never old in a strictly dynamic sense, for the processes, although they vary in intensity, vary little if at all in quality. However, a general view of streams or a combination of them reveals a certain cyclic sequence of events which it is the purpose of this paper to trace in orderly fashion. This sequence of events has been called the dynamic cycle.

The first hints of the dynamic cycle were observed on a hillside during a rainstorm. A fairly flat surface on rather compact material passed through enough of a miniature drainage cycle from the beginning of interlacing rills to the formation of master streamlets to give a momentary glimpse of the various steps in the cycle. Nothing further was done with the idea until the problems presented by the drainage and the land forms of southeastern Ohio suggested that a return to, and an intensive study of, the fundamental characteristics of stream development might throw light on the origin and history of the drainage and also facilitate an understanding of the geomorphologic history. The present paper is one of the results of that study.

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*Presented before the Geological Society of America at Washington, D. C., December 28, 1929.

[1] Dual Nature of Physiography. Science, Vol. 72, 3–5, 1930.

Subsequent field work included the further study of portions of the cycle passed through in miniature, and rather extensive observation during portions of four field seasons. The many different steps in the development of a drainage system may be observed separately on a large scale and later fitted together into an orderly sequence. Obviously the time required for the entire course of the cycle is too long to permit of direct observation.

An attempt has been made to follow the inductive method from the original observations to those made later and the whole tested and supplemented for synoptical reasons by map study. The United States Geological Survey topographic sheets of the eastern part of the country were consulted, about two hundred of the maps selected, and the drainage traced off. From these the illustrations here included were chosen to represent to a fair degree the sequence of events in the evolution of a drainage system. Maps of the late phases of the cycle were found in a region where the elevation of the level of base-level advanced the cycle sufficiently to give adequate illustrations.

The drainage cycle[2] falls naturally into two main sequential stages—extension and integration. Extension includes the sequence of events from initiation of the drainage system (in many cases the initiation of certain activities) until it, as a system or branchwork, completely occupies the basin. Integration includes the sequence of events from maximum extension to and through the emergence of master streams or master tributaries.

The scheme of development here presented will be given in a fashion as nearly ideal as possible, since departures or variations from the ideal for one reason or another will then be the more easily recognized and understood. The main body of the paper will trace the steps in the dynamic cycle and the discussions will consider some of the relationships between streams and their environment.

Assumptions and Definitions. — The initial assumptions include a certain uniformity of lithology, a simplicity of rock structure, and a humid climate like that of the eastern United States.

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[2] A summary view of the nearly ideal cycle appeared in the Geographical Review, July, 1931.

Any stream or branchwork of streams with a common point of discharge constitutes a drainage system. Rainwash from the dynamic standpoint includes all rain water that has not concentrated into definite streams which, after such concentration, form an organized part of a stream system.

The vertical distance through which rainwash travels on the ground is called the drainage relief and the ratio of the vertical to the horizontal distance covered at the same time is called the drainage ratio.

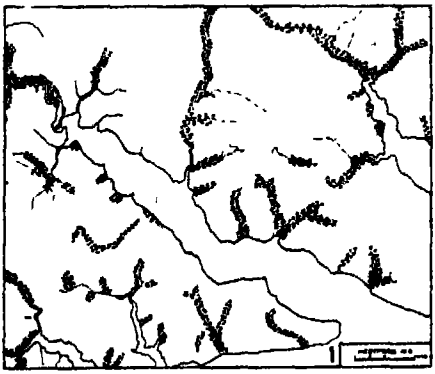
Acknowledgments.—The writer wishes to acknowledge his indebtedness to the Research Committee of the Graduate School of Ohio State University for a grant of funds with which he secured a research assistant to aid in the office work and the preparation of maps. He is also indebted to the Geological Department of Yale University, the Ohio Geological Survey, and the Department of Geology of Ohio State University for the use of maps and for office supplies. Sincere thanks are due these several organizations.

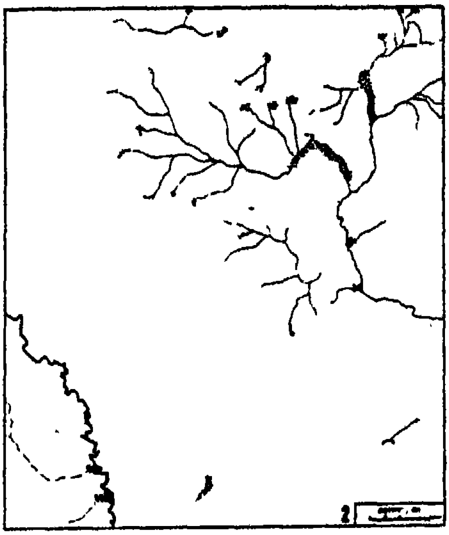
EXTENSION.

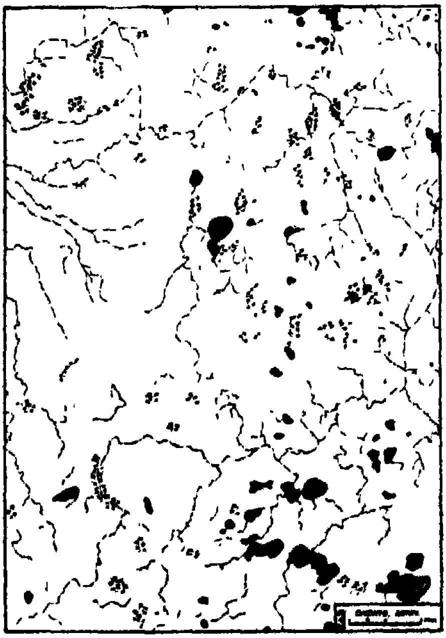
Initiation of the Drainage System.—The early and the late phases in the cycle are perhaps the most difficult of all to observe, to find on maps, and to picture mentally. Small scale observations give the best results, although on a very small area rainwash tends to overshadow the concentration of water into rills.

Figure 1 indicates what may be expected at the start of extension when drainage begins to be concentrated along definite paths. A number of the streams end without uniting into, or joining, a main, and swamps in some cases conveniently mark the courses of future streams. A large percentage of the surface lacks conspicuous channel-ways for the disposal of rain water. Though the coast has been drowned and the ground water surface has been elevated, yet the hints concerning the initiation of a drainage system appear clearly.

The streams on Figure 2 show a better degree of organization than those on Figure 1; they also show the disappearance in large measure of the indecision and hesitancy of pre-extension. Essential features of the future system have become apparent, although a few streams still end indefinitely. The blank







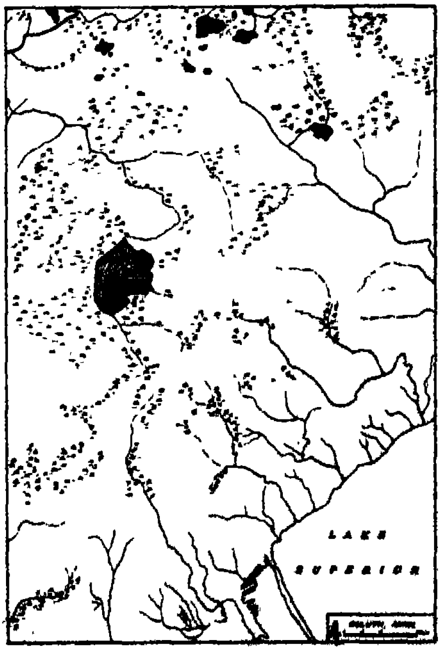


FIG. 1. The initiation of drainage systems; almost pre-extension for the most part.

FIG. 2. The start of dendritic extension. Swamps occur on uplands and lowlands. The probable role of swamps as indicating the courses of future streams is well shown on the central north-south strip of the Folkston, Georgia-Florida, topographic map.

FIG. 3. The first efforts toward organization and extension on a recently glaciated surface.

FIG. 4. The start of elongation. Poor organization. Both headward and mouthward elongation.

areas contain numerous shallow linear swamps which as features preceding actual streams are particularly well shown in the central part of the Folkston, Georgia-Florida, map.

Some parts of the Chokio, Minnesota, sheet (Figure 3) show the first efforts of the run-off to concentrate along definite paths, the first efforts toward organization on a recently glaciated surface. The inland part of the Duluth map (Figure 4) shows much the same condition save that, the topographic details being less minute than on the Chokio sheet, the initial stream courses are far less numerous, and hence the advance of the drainage cycle appears to be less rapid but more systematic.

Discussion.—Although rainwash dominates the time particularly before and during initiation, most of the land surface of the earth never leaves the rainwash stage. It is the task of a drainage system during extension to reduce the horizontal distance of rainwash travel to as small an amount as possible. From an areal standpoint, therefore, rainwash possesses far more importance than the streams to which the water is contributed.

The discovery of an ideal beginning for a drainage system, were such a thing possible, would be of great interest and utility. Four methods of origin come to mind: (1) headward growth of streams from what is commonly called the "gully stage," (2) the headward and mouthward growth and union of indefinite stream-ways into a unified stream discharging into another stream or body of standing water, (3) mouthward growth, and (4) combinations of the first three. The streams emptying directly into Lake Superior on Figure 4 appear to illustrate method (1), as do those on the north portion of Figure 5 neglecting drowning. The making of a hillside gully is a very common illustration of the first method, but many such gullies actually constitute in the end a phase of stream development by the second method.

The origin of a valley and the origin of a stream may differ to a considerable degree if the two be divorced temporarily. Part of the rain falling on a uniformly sloping area forms the run-off which attains sufficient volume to make definite streams long before the edge of lowest elevation is reached. At some place between the higher and lower edges, but closer to the upper, streams will normally begin.[3] Conspicuous gullies, in contrast, tend to form at the lower edge and thence lengthen upstream in such fashion as to produce a break in the longitudinal profile of the valley. Profile breaks like these testify to a certain lack of simultaneity in the origin of a stream and the origin of a definite valley. They are by no means uncommon features and of course come to mind at once in relation to rejuvenated streams. A topographical and historical analysis of the short streams to Lake Superior on Figure 4 reveals the fact that their mouths have been elongated by lowering of the lake level (method 3) and their heads have been lengthened partly by means of method (1) and partly by means of method (2). In truth, the question may be raised whether any stream branching away from a main ever attained full size solely by wash at the gully head or, for that matter, by any single method of growth.

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[3] See for instance: Marr, J. E. The scientific study of scenery. London, 1900. Pp. 72-75. Wentworth, C. K. Principles of stream erosion in Hawaii. Journ. Geol., Vol. 36, 398. 1928.

The streams on the remainder of Figures 4 and 5 and also those on Figure 3 subscribe to method (2) in origin. Rain falling on a new land surface seeks out all low places and the discovery of sloping linear depressions permits the formation of incipient streams. The union of such embryonic streams with each other or with an established waterway marks the origin of a definite stream (but not necessarily an erosional valley in entirety) and the beginning of the stage of extension.

In conclusion it may be said that many local streams and small tributaries have with little doubt been started from the "gully stage," though the gully is far more important in the history of a valley than in the development of the stream; and that most of the larger streams and the chief parts of drainage systems have originated in a more complex fashion than implied in the development of a gully.

Initiation on the whole is a time when such streams as do exist lack organization, when hesitation and indecision rather than systematized invasion of the land governs the run-off, and when rainwash overshadows all other processes. Initiation refers not only to the beginning of streams but also, and more especially, to the beginning of extensional activities. A continuation of these activities constitutes the stage of extension.

Elongation of Streams.—Elongation refers to all manner of stream lengthening. The first hints of systematic elongation indicate the existence of extension. Two directions of lengthening may be observed: headward into unoccupied land inherited from a formative agency, as glaciation, and mouthward over a newly emerged area.

All maps in the first part of the paper show elongation of one type or another. The main streams on Figure 6 not only show headward elongation, but also suggest the possibility of future competition which will arise because of such elongation. Additional examples may be seen on Figures 1, 2, 4 and 5.

Growth in the opposite direction, mouthward, is much less emphasized in geologic literature and less well developed in our ideas of stream history. Mouthward elongation has been called "progression" by Doctor W. Armstrong Price,[4] the progressive river being one "which grows outward across a rising coastal plain." However, the type of lengthening here considered is far more general in application, referring to all lengthening accomplished in the mouthward direction as the following examples indicate. The streams flowing into the Glacial Lake Agassiz lengthened mouthward as the lake contracted and withdrew to northward. Figure 7 shows the result at one locality. Such direction of growth was not always exactly parallel to the older part of the stream; in some cases the elongated portion made high angles with the original course[5] or even reversed its direction.

In fact mouthward elongation has been very common in the areas contiguous to the Great Lakes. Postglacial streams, independent of preglacial channels,[6] now flow over the beds of glacial lakes into the present Lake Superior, having entered Lake Duluth and successively afterward, Lake Algonquin and the Nipissing Great Lakes prior to the existence of Lake Superior. St. Louis River likewise lengthened its lower course[7] to follow the receding waters of Lake Duluth. The streams along the western and southern margins of Lake Erie have had the same history, illustrated in one case by the Fremont, Ohio, sheet (Figure 8).

Elongation serves to get the stage of extension under way, to produce a skeletonized drainage system, and by so doing, to eliminate the initial abbreviated streams.

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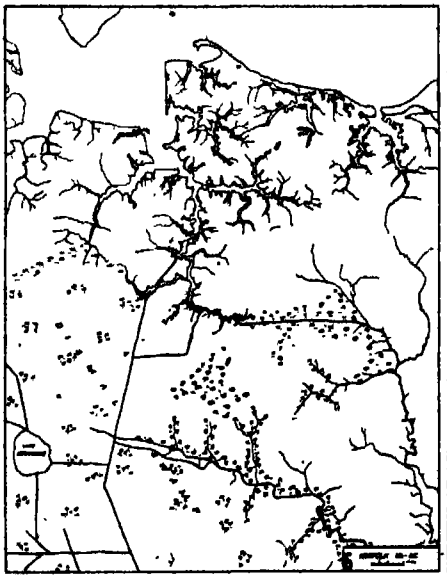
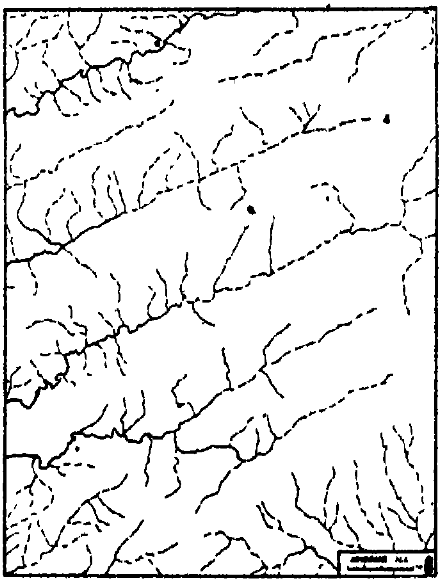
[4] Personal communication, March 26, 1930.

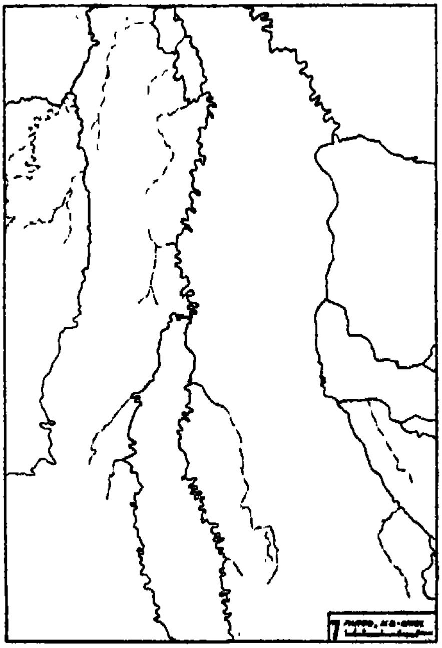
[5] Upham, Warren. The Glacial Lake Agassiz, U. S. Geol. Survey, Mono. 25, 19–20, 54–57; Pls. 3 and 25. 1896.

[6] Leverett, F. Moraines and shore lines of the Lake Superior region, U. S. Geol. Survey, Prof. Paper 154-A, 8. 1929. Plate 2 shows the many short streams entering Lake Superior.

[7] Ibid, 10.







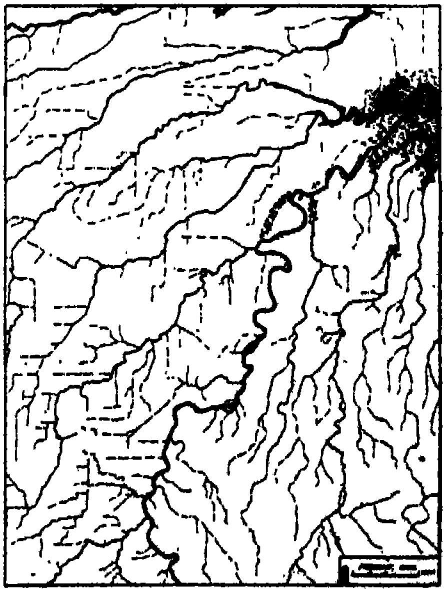


FIG. 5. Early extension and headward elongation.

Fig. 6. The stage of extension on a drift plain; elongation fairly complete, elaboration started. Parallel headward elongation.

FIG. 7. Early extension on a lake plain. Parallel mouthward elongation. Elaboration barely begun.

FIG. 8. Mouthward elongation over a lake plain.

Discussion.—The word "extended" has been applied[8] on several occasions to rivers lengthened mouthward. Since the term does not enjoy common usage, its application, in the altered form "extension," has been broadened for use in connection with the first stage of the dynamic cycle, and the more simple designation lengthening, or elongation, employed for linear growth.

Mouthward lengthening and shortening undoubtedly have played an important part in the geologic history[9] of streams. A well-known example is the gradual growth of Mississippi River from southern Illinois to the present Gulf of Mexico. A case of equal if not greater interest lies in the growth of streams which follow a sea retreating out over a rather uniform slope. The arrangement[10] of the main streams on the Piedmont Plateau suggests the hypothesis that they have evolved in much the same fashion as those on the Atlantic Coastal Plain whose growth taken algebraically has been mouthward incident to a receding shore line. Consequently, the coastal plain sediments,[11] of whatever thickness, may once have extended over much if not all the Piedmont Province. At least an analysis of the drainage in the large suggests such an hypothesis applied here, however, only to the streams of the Piedmont. The case of the Potomac and the Susquehanna where they cross the mountain and valley belts does not appear with equal clarity from the present study.

Mouthward elongation deserves to be ranked along with headward and it is only just in view of the facts to consider them of equal importance. This much may be ventured as a tentative opinion: that mouthward elongation of the trunk

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[8] Davis, W. M. Geographical Essays. Boston, 1909. P. 181. Grabau, A. W. Textbook of Geology. Boston, 1920. Part I, p. 712. Cotton, C. A. Geomorphology of New Zealand. Wellington, 1922. P. 70.

[9] Some recent publications of significant interest are:

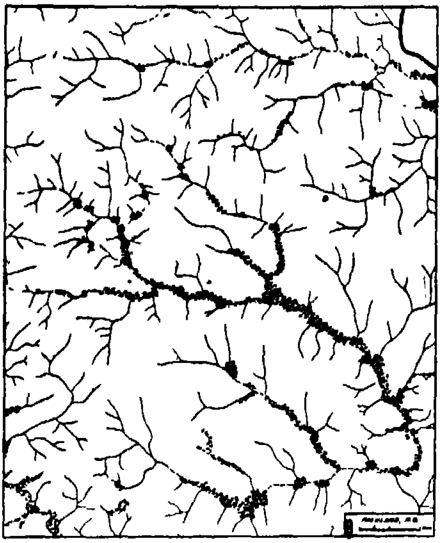
Adams, George I. The course of the Tennessee River and the physiography of the southern Appalachian region. Journ. Geol., Vol. 36, 481–493. 1928.

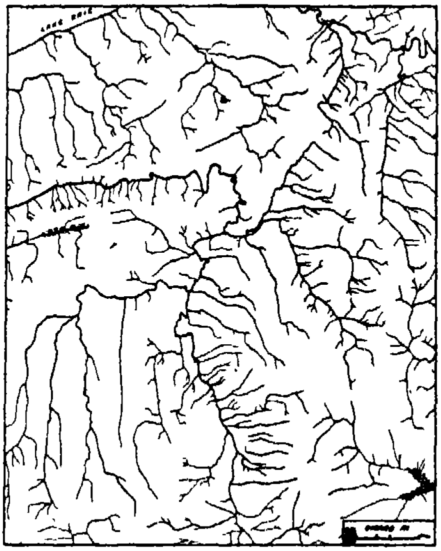
Adams, George I. The streams of the coastal plain of Alabama and the Lafayette problem. Journ. Geol., Vol. 37, 193–203. 1929.

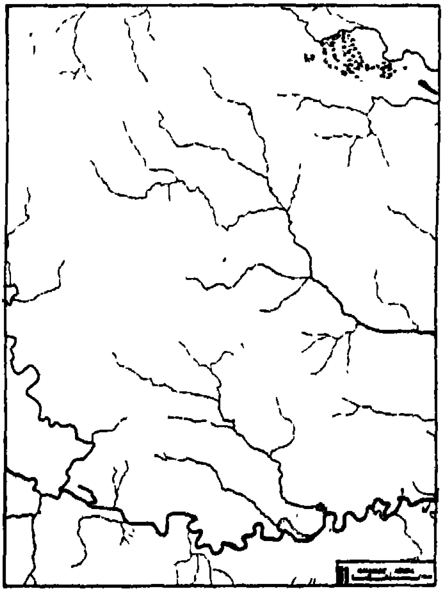
Flint, Richard Foster. Pleistocene terraces of the Lower Connecticut valley. Bull. Geol. Soc. Amer., Vol. 39, 980–981. 1928.

[10] See Chamberlin and Salisbury. Geology. New York, 1906. Vol. 1, p. 168, Fig. 160, or a drainage map of the United States. Also, Cotton, C. A. Geomorphology of New Zealand. Wellington, 1922. Pp. 69–70.

[11] Doctor D. W. Johnson, at the Toronto meetings of the Geological Society of America, December 30, 1930, presented the theory that the coastal plain sediments formerly may have extended 125 to 200 miles farther northwestward than they do now.







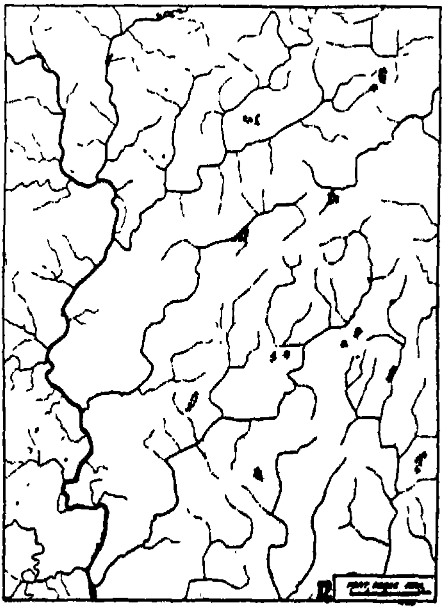


FIG. 9. Dendritic elongation and extension.

FIG. 10. A study in direction and pattern of elongation, showing mouthward and headward direction of lengthening as well as parallel and dendritic patterns.

FIG. 11. Elongation incomplete; elaboration scarcely started. Chiefly Wisconsin drift. Figs. 11–14 show the progress of elaboration.

FIG. 12. Elongation almost complete; elaboration started. Wisconsin drift.

portions of a drainage system has far more importance in the history of such a system than has headward elongation considered over a region and over a period of time.

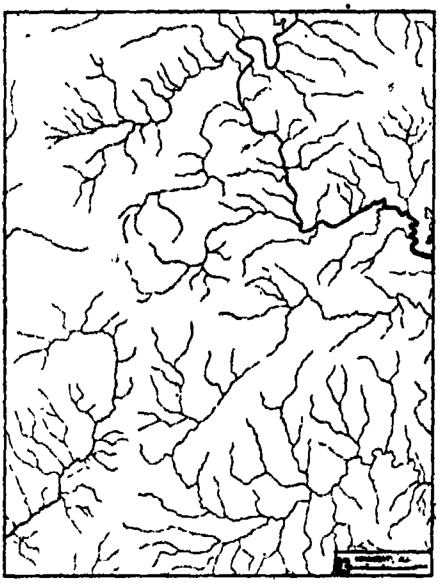
Headward elongation is most aggressive where there is an optimum amount of slope and uniformity of surface. A surface like that on the Chokio quadrangle is inimical to steadily progressive and rapid headward growth. On the other hand, if the slope is too steep, headward growth apparently is retarded, as for example on the Allegheny ridges. The cause for the retardation lies among several factors such as thinness of soil, ground water surface, vegetation cover, nature of the rock, and the gradient of the run-off, all of which seemingly conspire to deliver the water in concentrated form at a comparatively low elevation on the mountain side. There must be some optimum slope and surface.

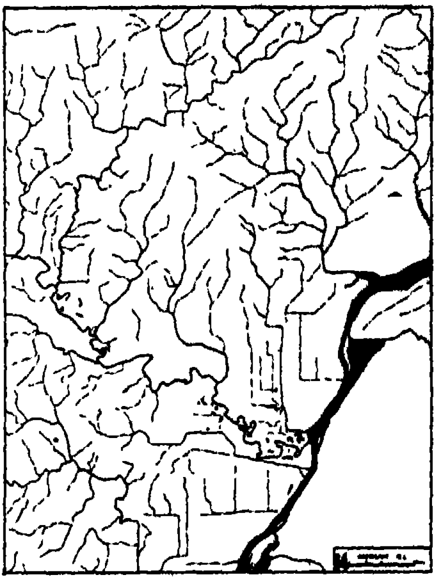
The subject of stream lengthening is complicated and perhaps merits more discussion than space permits. It is worthy of mention from the historical standpoint, however, that many streams undoubtedly have been lengthened headward following a waning ice sheet. An interesting study of stream growth in a mouthward direction may be made along shores as the waves recede and the tide goes out.

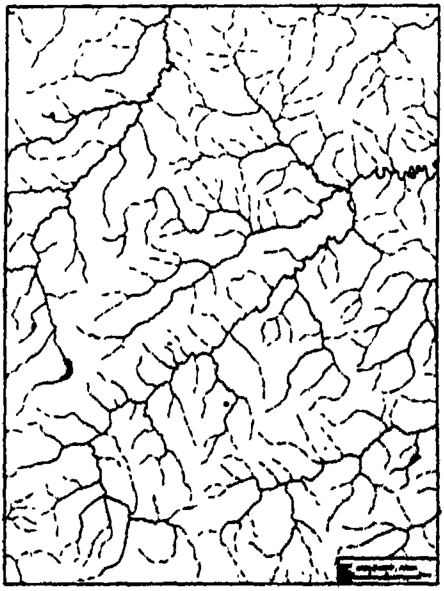
Elaboration of the System.—Elaboration refers to the constant development of minor tributaries which fill in the main body, or framework, of the growing system. The initially elongated system is expanded and embellished internally.

The Fargo map better than any other shows elongated streams with a minimum addition of tributaries. Elaboration may be followed as a progressive affair on the series of maps, Figures 11, 12, 13, 14, and 15, so chosen as to represent approximately the same relative positions with respect to the particular drainage systems. On the Waukee sheet the process of elaboration has just begun, whereas on the Melcher the branchwork of streams is fairly complex, most of the surface has been invaded, and the process therefore is approaching completion.

Elaboration eliminates the skeletonized form produced by elongation. The process constantly adds tributaries of decreasing rank until the branchwork, as a system of drainage, is fully elaborated. A system may be considered full-grown when it fulfills certain requirements discussed subsequently under the topic maximum extension.







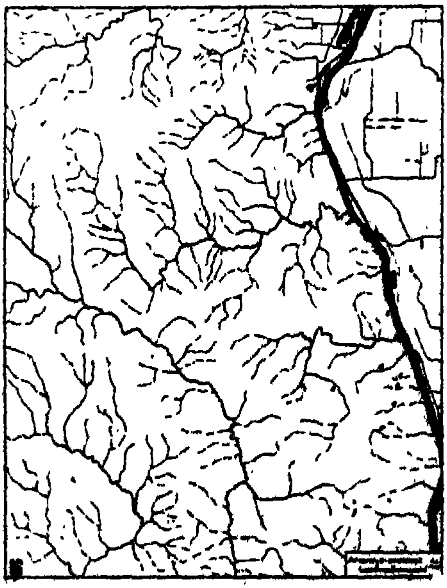


FIG. 13. Elongation practically complete; elaboration well begun. Illinoian drift.

FIG. 14. Elongation done; fairly well elaborated. Illinoian drift.

FIG. 15. Elongation done; elaboration far along. Kansan drift.

FIG. 16. Territorial aggression. Stream A is the aggressor. Streams B, C, D, E, and F have been repressed. Stream F is submissive. Stage of extension.

Discussion.—Elongation and elaboration constitute the stage of extension; the two seldom can be separated save for mental convenience. Local elongation, however, must precede the addition of tributaries at any particular place. On the whole, lengthening applies equally as well to individual streams as to systems while elaboration can refer only to an entire system or a unit part of one. A stream or system once established must in the nature of things always continue its efforts to lengthen and expand, at least as long as the laws governing extension remain in operation. This apparently must be so, since extension is typified by the attempt to shorten the distance of rainwash travel. Competition arises not only among streams but also among drainage systems because of the inexorable desire to grow, and the satisfying of this desire carries the activities of extension, though not the stage itself, over into the stage of integration.

Perhaps the series of maps, Figures 11 to 15, deserves a further remark: the older drift sheets possess the more elaborate drainage systems, which alone would occasion no comment were it not for the fact that these particular maps were placed in sequence quite without forethought while a large number of maps were being analyzed and arranged in order. They were selected because of their closely similar positions in their respective drainage systems and only then were the particular drift sheets determined.

Pattern of Extension.—The patterns assumed by stream systems because of extension will be mentioned only in so far as a simplified analysis of the stage requires; the complete sequence of pattern development will not be considered. Maps such as shown on Figures 6, 7, and 8 illustrate parallel elongation, a very common type apparently if extension is in its early phases, or if the initial surface is of rather uniform nature and of definite slope, or if elongation occurs in a mouthward direction. (Of course the parallel pattern also develops under structural and lithologic control.) The influence of surface and slope becomes apparent in a study of the shoe string type of rills. The parallel arrangement develops gradually into a parallelo-dendritic pattern in absence of structural control and the original pattern may be restored in the main by blotting out the branchwork of tributaries fastened onto the mains.

The dendritic is the contrasted type of pattern which develops because of the nature of the surface, the regional slope (or absence of it), and the materials. Figures 1, 2, 3, the north part of 4, and 5 show this type of extension on various surfaces. On figure 9 the dendritic pattern of lengthening applies equally well to different tributary groups.

Discussion.—A mention of dendritic pattern suggests the word "insequent" as used by Davis to[12] designate so-called self-guided streams, i.e., expanding stream systems controlled neither by initial slope, nor by difference of rock resistance, nor by structure.[13] Is this, however, a true lack of control even though the influence does not seem so definite as in the case of structurally controlled streams? In any case, insequent expresses a relation between surface and drainage and, though there is probably nothing fundamentally wrong with "insequent pattern," yet the word dendritic is much more generally used.

Although the dynamic viewpoint recognizes two fairly distinct types of pattern, the fact remains that variations and combinations of the two exist because of the influence of surface and material. Figure 10, illustrating not only both directions of elongation but also both patterns, furnishes a highly interesting study of surface form in relation to stream development from the short tributaries entering Lake Erie to the parallel streams in the southwest one-quarter of the map flowing down the back slope of a morainic ridge.[14]

Behavior of Streams During Extension.—A study of streams during extension reveals two contrasted types of behavior, *permissive* and *aggressive.* Permissive refers to the type whereby a stream or system extends into territory rightfully belonging to it in the course of natural development—that territory which it would be expected to occupy because of its position and relations. Each system develops normally in all its parts and drains a basin acquired by minimum encroachment on adjoining systems. Permissive behavior borders on the ideal since it requires fair play and an equitable distribution of territory, obviously a behavior calling for an unusual uniformity of surface, slope, material, and distribution of streams.

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[12] Davis, W. M. Geographical Essays. Boston, 1909. P. 174.

[13] For these controls see: Tarr and Martin. College Physiography. New York, 1920. P. 186. Grabau, A. W. Textbook of Geology. Boston, 1920. Part 1, p. 712. Lahee, F. H. Field Geology. New York, 1916. Pp. 336–339. Tarr and Martin say: "This insequent stream pattern is often treelike, for which reason the drainage is said to be dendritic."

[14] Leverett, Frank. Glacial formations and drainage features of the Erie and Ohio Basins. U. S. Geol. Survey, Mono. 41, plate 15. 1902.

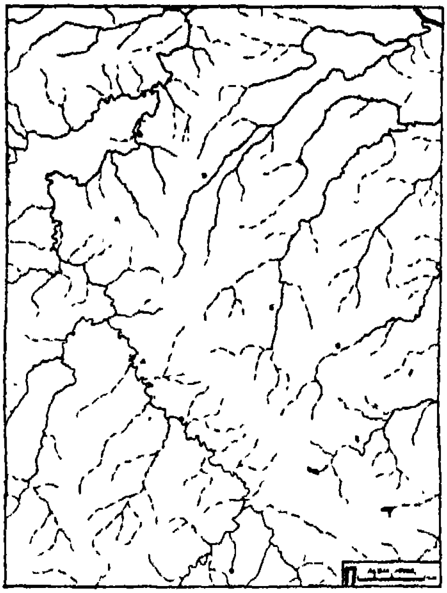
The early phases of extension, to be sure, witness the permissive type of behavior to a much more perfect degree in the normal order of events than do the late phases. A study of ideal behavior has certain value for, if a drainage system is chosen at random and superimposed upon a chart showing the same system developed under ideally permissive behavior, any accidents, variations, or abnormal development may be detected. This can be done in very simple fashion with Figure 24.

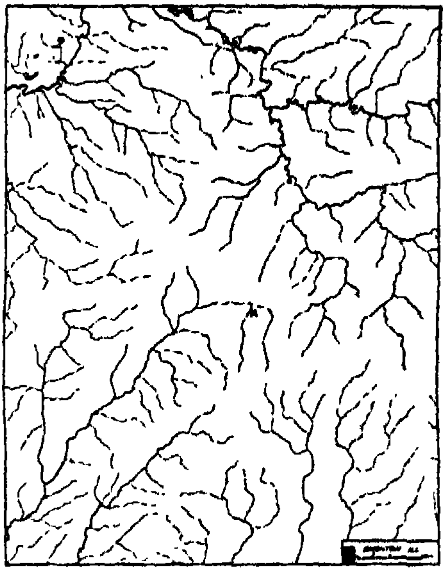
Aggressive extension refers to the behavior by which foreign territory or neighboring streams are captured. Hence, there may be aggression (1) as to territory and (2) as to streams.

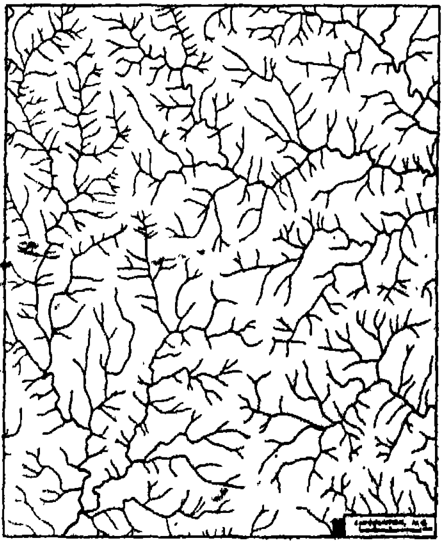
(1) On Figure 16 stream A has entered territory which belongs on general principles apparently to streams B, C, D, E, and F, and for that reason A is the aggressor. Streams B, C, D, and E have been repressed. Stream F is submissive because it has continued to grow, in a *different direction*, after repression. On figure 17, B, C, D, and E have been repressed by A. The principles governing aggressive and permissive extension will permit an interesting study of drainage behavior on the maps so far mentioned.

(2) Aggression with respect to streams is simply piracy as commonly understood. The type of piracy depends upon the impelling reason for the behavior; for instance, extension piracy has occurred on figure 18 at A. Since the larger streams crossing a barrier of resistant rock will cut down rapidly, tributaries to them will behave aggressively with respect to the smaller streams crossing the barrier and steal their headwaters. The smaller streams have been beheaded by the aggressive activities of the larger.

Discussion.—A realization that streams can be studied from the standpoint of behavior gives a clearer understanding of stream history in certain cases and a different method of approach to the study of land forms. Stream systems possessing obvious irregularities either have departed from a previous ideal scheme of development or are themselves more or less notable departures because of special initial, or inherited, conditions of the basin, and hence normal to those special conditions. Field observations should in most cases be the decisive criterion of differentiation. In any case, a concept of the ideal system and a knowledge of the variations will aid materially in deciphering the history of a system, in reconstructing the original surface, or both.







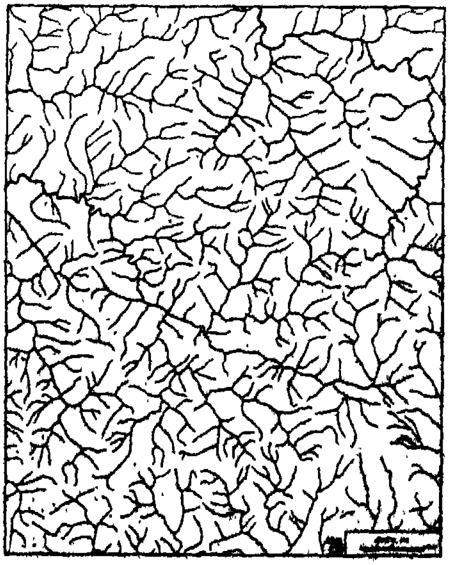


FIG. 17. Territorial aggression on a larger scale than on Fig. 16. Stream A, the aggressor, has repressed streams B, C, D, and E. Stage of extension.

FIG. 18. Aggression with respect to streams. Extension piracy has occurred at A. Extension well along.

FIG. 19. Maximum extension on the inner Piedmont Plateau. Coarse texture.

FIG. 20. Maximum extension on the Appalachian Plateau. Medium texture.

Although there are reasons for thinking that aggressive extension is a more normal affair than permissive, a knowledge of the latter facilitates an understanding of the methods, results, and relations of aggression. Very little if any aggression occurs during the initiation of a drainage system but it waxes greater as extension progresses and reaches a maximum as contiguous systems approach full development. Territorial aggression attains a maximum sooner than stream aggression.

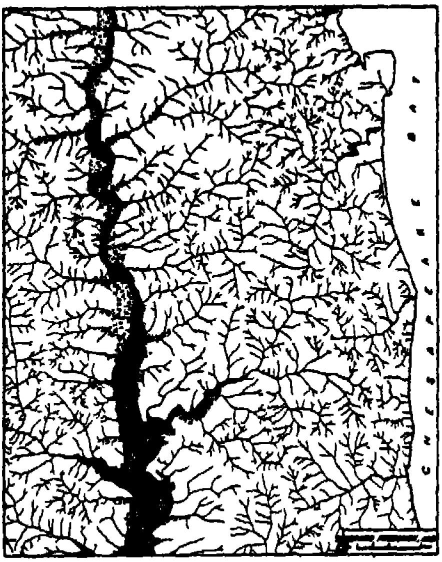
Maximum Extension.—A system reaches maximum extension when elongation and elaboration have been completed—when the territory rightfully belonging to the system has been completely occupied. Active competition with contiguous systems, if such occurs, must therefore come for the most part after the attainment of maximum extension.

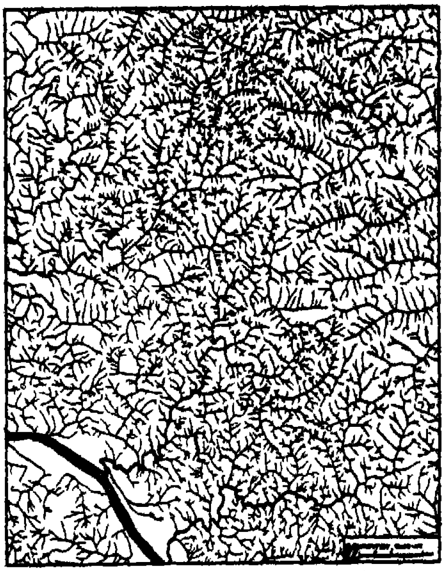
Figure 15 has the best developed drainage of any map among those so far given. Several varieties of maximum extension are shown on Figures 19, 20, 21, and 22, among which Figure 19 is slightly less well developed than the remaining three. The Lincolnton map is taken from a region of moderate relief on the inner Piedmont Plateau; the Bucu from a region of rather high relief on the Appalachian Plateau; the Prince Frederick from an area of low relief on the west shore of Chesapeake Bay; and the Ironton from an area of moderate relief near the west border of the Appalachian Plateau. The last two possess a fine texture.

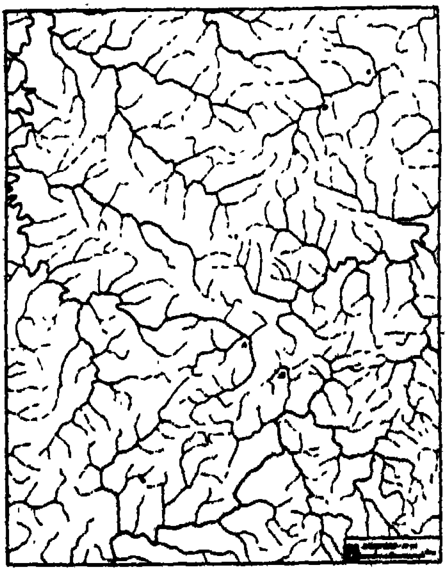
Maximum extension is characterized by a lack of intermittent streams and by the presence of fully elaborated systems. It is first attained when the territory comes to be fully occupied by streams.

Discussion.—Extension is the stage wherein each system is impelled by the desire to shorten the distance of rainwash travel as much as possible by the lengthening of existing streams and by the addition of tributaries. In other words, extension is a process which attempts to increase the so-called drainage ratio until it reaches the maximum possible, that is, unity under ordinary circumstances, or a 45 degree slope. Exceptional slopes may, of course, be steeper. Nevertheless, this fixes mathematically and dynamically the time when maximum extension is attained at any locality, and an algebraic average applies to a system as a whole.

The query may arise as to whether any aggression either in respect to territory or to streams should be included within







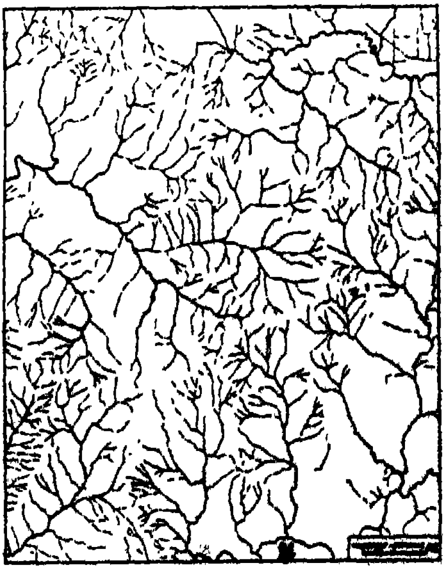


FIG. 21. Maximum extension along west shore of Chesapeake Bay. Fine texture.

FIG. 22. Maximum extension at west border of Appalachian Plateau. Very fine texture.

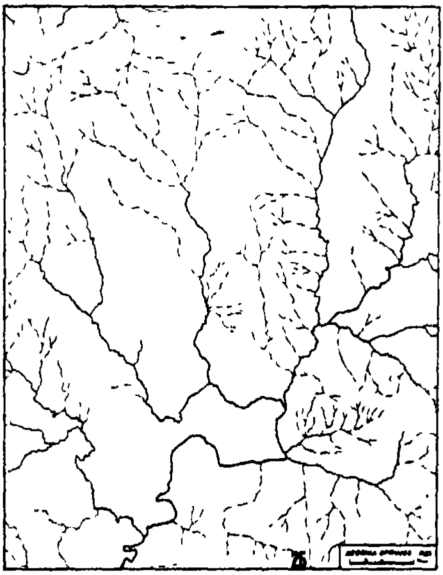
FIG. 23. Maximum extension definitely past. The piracy at A, B, C, and D indicate that the systems had been fully extended prior to the present. Intermittency has returned.

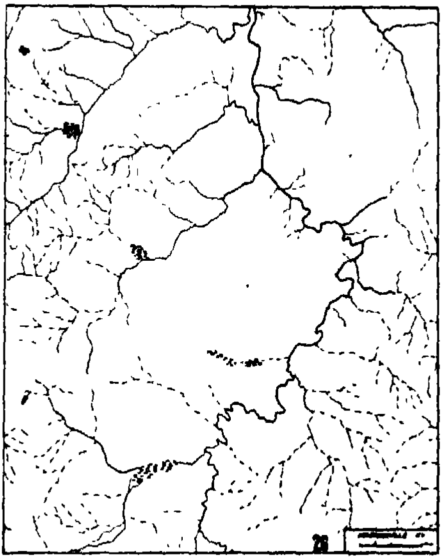
FIG. 24. Early integration. Abstraction and absorption started.

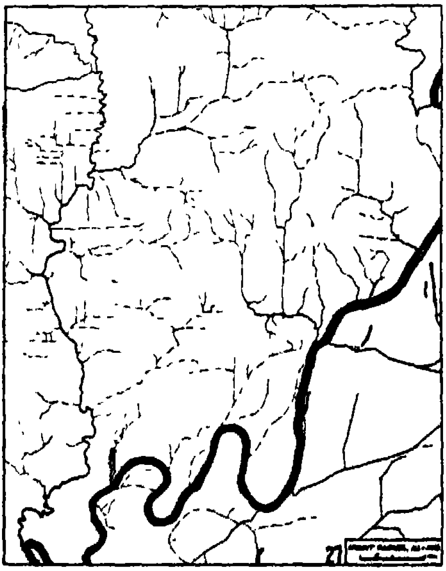
the limits of the stage of extension. When a drainage system in a given region first and fully drains that region then the *stage* of extension has attained maximum. The climax of competitive aggression therefore occurs after the complete occupation of the drainage basin. Such a concept appears logical because of observation, because of its simplicity and utility, and because of the nature of the dynamic scheme. A map will serve as an illustration of the point. The piracy, as at A, B, C, and D, Figure 23, gives evidence that the territory had been completely occupied at some time in the past and for that reason the system is now post-maximum extension.

Maximum extension also represents the transition from extension to integration. At times maximum extension is a very brief interval; at others it is of considerable length. If the interval be long the dynamic cycle appears to include three stages rather than two. However, drainage systems considered dynamically pass through two distinct stages only—extension and integration—which account for practically all of the activities. Some activities may well occur after maximum extension is attained, but before integration becomes *evident*. The trunk areas of a system in a region of small drainage relief begin the processes of integration with little doubt long before the outlying parts of the system have finished extension.

No reference has yet been made to the change from intermittent to permanent streams during the progress of extension. If the maps are viewed in sequence it will be seen that intermittency disappears headward as extension progresses, that it is entirely absent at maximum extension, and that it reappears especially among tributaries with the progress of integration. This change of character, which is essentially a change of relationships, depends largely upon the depth, shape, and gradient of the ground water surface, the variation in the amount of run-off discharged to streams, and the depth of soil cover. During extension the ground water surface characteristically lies below the valley bottoms of many tributaries. All streams, however, apparently intersect the surface at maximum extension, a time when that surface possesses its steepest gradients and greatest local variations in altitude. With the progress of integration the ground water surface appears to be lowered and flattened. Decreasing rainfall incident to decreasing elevation in a region of initially high







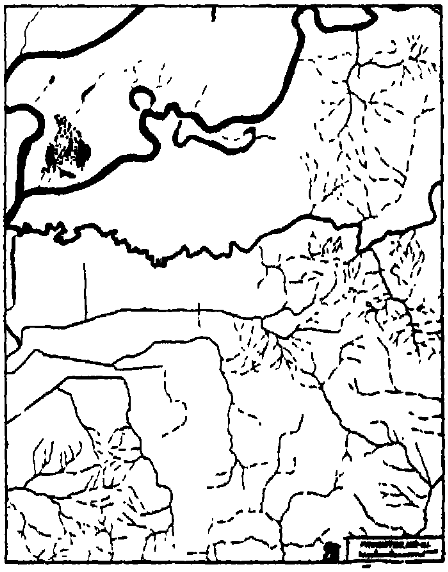


FIG. 25. Integration well started. The emergence of master tributaries.
FIG. 26. Integration rather far along. Abstraction quite evident.
FIG. 27. Rather advanced integration.
FIG. 28. Advanced integration. Master streams and master tributaries.

altitude undoubtedly is a factor[15] in the supply of ground water, but does not appear to apply in the case of the above-mentioned problem since the cycle of intermittency exists in regions of low as well as high elevation.

A study of the dynamic cycle has opened up a highly interesting problem on the relations between ground water and the history of the cycle.

INTEGRATION.

Extension is a time of increasing complexity, integration a time of simplification. The drainage system during integration maintains its control over acquired territory and at the same time consolidates its holdings, as it were, by a marked reduction in the number of tributaries, by the return of intermittent streams, and finally, by the emergence of master streams and master tributaries.

A thorough description and consideration of the detailed phases of integration are very much more difficult tasks than they are for extension because of the paucity of examples on present land surfaces. Some of the activities may be observed in a miniature fashion, but rarely on a large scale. The maps used as illustrations have been chosen to show the sequence of events to the best advantage for the size of the area.

The reappearance of the skeletonized form signalizes the definite existence of integration such as shown in Figure 24. Further progress of the stage appears on Figures 25, 26, 27, and 28, in a sequence which shows continued decrease in the number of streams, the spread of intermittency, and the gradual accentuation of the master tributaries. Figure 26 lies about intermediate in the progress of integration between Figures 24 and 25 and Figures 27 and 28. Of the series, the Princeton map (Figure 28) has progressed the furthest and it is of interest to notice that the Haubstadt map (Figure 24) which adjoins the Princeton on the south occupies a position somewhat more removed from the chief regional streams. The maps reproduced are fairly typical and represent, in rather brief fashion to be sure, several steps in integration. Maps from the lower Mississippi region show too small a section of the drainage system to be of comparative value.

The activities or processes responsible for the progress of integration appear to be abstraction, absorption, and a type of aggression.

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[15] Davis, W. M. Geographical Essays. Boston, 1909. P. 262.

Abstraction.—Gilbert[16] defined the term as follows, "A stream which for any reason is able to corrade its bottom more rapidly than do its neighbors, expands its valley at their expense, and eventually 'abstracts' them." The idea is employed here in exactly the same sense save that the effects of lateral corrasion are also included.

Thus, abstraction is the elimination of tributaries, commonly of the shorter type, by the lateral and vertical migration of the main; it is also the loss of identity and personal independence of a secondary on the meander belt of the primary. The lateral migration constantly increases the immediate drainage area of the master itself at the expense of its tributaries. In this way, the lower part of a tributary system may be dismembered or a tributary may be distinctly shortened so that it ends at the base of the valley wall. An example, indefinite in the sense that it reverses the order of events, is shown on Figure 26 slightly northeast of the center. The main stream appears (on the topographic map) to lie sufficiently below the general valley bottom to permit the origin and growth of several small tributaries. Now, these tributaries in their recent formation illustrate, in reverse order, the elimination of just such streams by lateral swinging in the construction of a flood plain.

The elimination of streams because of vertical migration of the main, if such occurs, belongs properly to the stage of extension and therefore abstraction actually begins during extension but becomes neither predominant nor prominent in the sense here employed until after maximum extension has passed.

Absorption refers to the disappearance of streams permanently or partially probably because of a general flattening of the ground water surface and its consequent depression below the valley bottoms. The first step is the return to intermittency; the second, the complete elimination of the stream save during the immediate discharge of rainfall. Absorption is undoubtedly responsible not only for the disappearance of many small tributaries, but also for the return of intermittency in the whole headwaters area of a drainage system during the progress of integration.

Route to the Sea.—The attempt made by a master stream to secure the shortest valley route to the sea in harmony with the regional slope of a subdued or peneplain surface has been called aggression for want of a better name. Since the process depends upon stream activity and upon decreasing environmental control, it is classed under dynamic activities. The laws of flow are ultimately based on gravity and streams therefore desire the shortest route to their outlets, a desire the more nearly fulfilled as factors of environment, except regional slope, relinquish control.

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[16] Gilbert, G. K. Report on the geology of the Henry Mountains. U. S. Geog. and Geol. Survey of the Rocky Mtn. Region, Washington, 1877. P. 141.

Geological history probably must be called upon for examples. The Delaware, the Susquehanna, and the Potomac were true *integrational consequents* if they took approximately their present courses on a peneplain surface.

Results.—The net results of abstraction and absorption are the elimination of a host of tributaries from the plexus of streams in existence during maximum extension, the simultaneous accentuation of certain streams which finally emerge as master tributaries, and the production of a skeletonized framework just as typical in its way of late integration as the previous skeletal outline was of early extension.

RELATIONSHIPS.

The details in the development of a drainage system, especially those having to do with pattern and behavior, depend upon the nature of the surface, the slope, the material, and the structure. In the present work, adjustments to diverse structures and variable composition have not been considered. Uniformity of material and simplicity of structure have been assumed in order to keep the scheme as near the ideal as possible. The influence of those factors may then be treated as producing variations from the ideal, or simplified, scheme of development.

There is no intention to minimize the importance of land form or the influence of rock structure and lithology. Yet upon strict analysis, rock and structure may modify the valley form or the position of a stream but they can not alter the nature of the dynamic processes or the stream activities. The entire cycle as here outlined may even be considered to belong within the border-land connecting the active and passive phases of physiography. If so, the dynamic cycle has this distinctive feature: its origin is in the geodynamic rather than in the geomorphologic viewpoint.

However that may be, many features characteristic of the pattern of a drainage system depend clearly upon the influence of geologic environment. Stream adjustment is merely one example. A consideration of such environmental influences lies outside the province of the present paper; moreover they have been fully and admirably discussed by others.

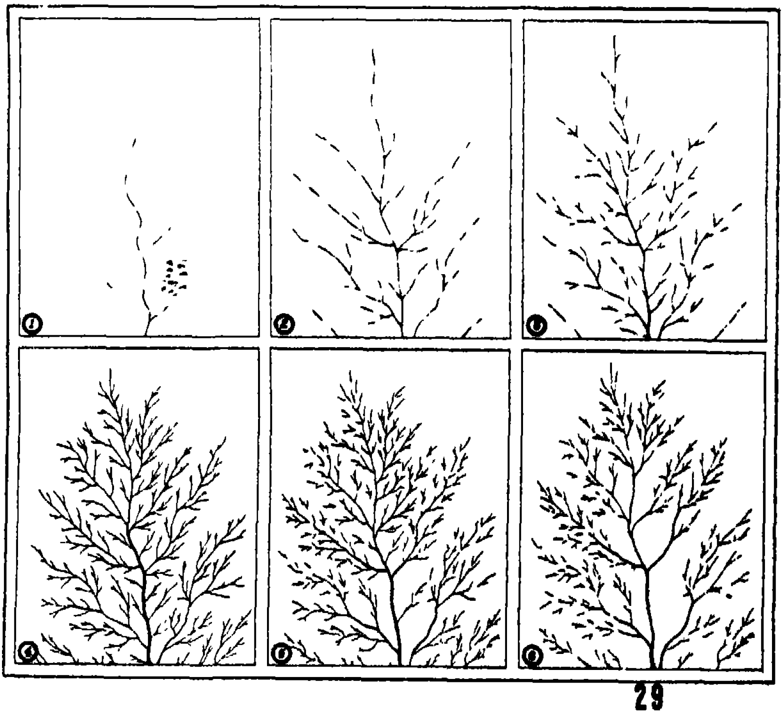

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Fig. 29. A summary diagram of the dynamic cycle: (1) initiation, (2) elongation, (3) elaboration, (4) maximum extension, (5) abstraction and absorption during integration, and (6) the emergence of master tributaries.

It will have been noticed that practically all of the illustrations have been taken from the humid portion of the United States. A drier climate undoubtedly would result in the following features in contrast with those described above: a great increase of intermittency; somewhat retarded elongation; poorly developed elaboration; a more skeletonized form at maximum extension; and an accentuation of the absorption process. On the whole the drainage system would be retarded in rate of development and would never attain the complex elaboration characteristic of a system under a humid climate.

Highly pervious rocks would have the same effect in some respects as a dry climate.

SUMMARY.

Figure 29 is an ideal summary of the dynamic cycle.

Classification is a matter of convenience, an expedient permitting us in many instances to grasp certain concepts and to transfer them to others. The drainage cycle actually knows no distinct subdivisions, although it does divide itself into general stages governed by certain prominent characteristics. Phases akin to extension may extend far into integration; and integration may begin its activities locally early in extension. The drainage system taken throughout its cyclic history reveals no sharp boundaries, no lines of cleavage where one set of characteristics ends and another begins. Only a preponderance of process or activity justifies the privilege of classification.

The dynamic cycle includes the history of a drainage system from initiation through the stages of extension and integration, or to the event whereby initiation begins anew. Strictly, the dynamic cycle refers to a series of events repeated cyclically and characterized by two sets of activities of which one set dominates extension and the other dominates integration. Diastrophism not only motivates the cycle but also initiates or interrupts it. Climate apparently regulates the intensity of the extensional activities, elongation and especially elaboration. The relations between climate and ground water must bear directly upon the very nature of the cycle itself. If so, several interesting problems await solution.

At the beginning of extension initial streams are elongated and the system is elaborated by the addition of tributaries of constantly decreasing importance until the fully developed branch-work occupies the basin blocked out originally by the elongated streams when they first made drainage contact with adjoining systems. Abbreviated streams and the skeletonized form have disappeared at maximum extension which, expressed more precisely, is attained when the so-called drainage ratio reaches a maximum. Intermittency has at the same time decreased to zero.

Integration in a measure reverses the processes of extension, for abstraction and absorption eliminate tributaries until merely a skeletonized framework remains to care for drainage.

Intermittency returns and spreads progressively among the tributaries. During the final phases of integration so far recognized emphasis is placed upon certain members of the system whereby master tributaries come to dominate the ultimate skeletal system, and the trunk stream seeks the shortest valley route to a point of discharge consistent with regional slope. The cycle may then be repeated or else terminated in accordance with subsequent diastrophism.

Extension is a time of conquest and minute invasion; integration a time of withdrawal and consolidation. In the whole story the rôle of climate, ground water, the drainage-ratio factor, and their mutual relationships appear to be of paramount importance in the evolution of the dynamic cycle.

THE EPIBRANCHIAL GANGLION OF THE GLOSSOPHARYNGEAL NERVE IN AMBLYSTOMA JEFFERSONIANUM.

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INTRODUCTION.

The epibranchial placode of the glossopharyngeal nerve in *Amblystoma jeffersonianum* has many characteristics in common with that of the facial nerve, but differs in the relation of the placode to the endoderm of the pharyngeal pouch. The second or glossopharyngeal pouch forms an open gill slit while that on the first or facial pouch does not become patent and withdraws from the ectoderm, leaving a detached mass of endoderm which later disappears. As a result of the presence of a permanent contact between the endoderm of the pharyngeal pouch with the ectoderm which forms the branchial cleft, the epibranchial placode of the glossopharyngeal nerve remains for a long time in contact with the endoderm and becomes detached relatively late while the placode of the facial nerve becomes detached from the endoderm relatively early.

The origin of the placodes of both nerves furnish very definite and positive evidence of the derivation of the placode from ectoderm from which the placode later, after a growth period, becomes detached from the ectoderm, moves medially and rests on the dorsal surface of the endoderm of the pharyngeal pouch. After this migration it joins the remainder of the glossopharyngeal ganglion derived from the neural crest and from the lateralis placodes. It is not possible in the case of either ganglion to follow the epibranchial placode after the fusion of the placode with the remainder of the ganglion occurs, until the differentiation of the definitive ganglion cells takes place. Kostir (24) has done this for the 11.5 mm. embryo and the description of the more difficult stages to analyze follows his description.

Stone (22) has shown that the removal of the neural crest does not prevent the formation of the placodal ganglia and that the removal of the ectodermal placodes does prevent the formation of the placodal ganglia. In contrast to the experimental and embryological evidence derived from the urodeles, Adelman ('25) holds that in the white rat the placode arises as the result of the stimulus furnished by the neural crest and G. Elliot Smith ('28) quotes Hill to the effect that in echidna the placodes arise from the endoderm. Whatever value comparatively the evidence from fishes and urodeles may have it is positively against the theory that the epibranchial placodes arise as a result of the stimulus of the neural crest or that the placodes are endodermal in origin.

The author, Landacre ('10), has previously cited the evidence for the function of the epibranchial placode after joining the remainder of the cranial ganglia. It is briefly as follows: every nerve having gustatory fibers has an epibranchial ganglion; no nerve without an epibranchial ganglion has gustatory fibers; the size of the epibranchial ganglion is always proportional to the size of the epibranchial placode; in Ameiurus, which has an enormous epibranchial placode on the glossopharyngeal nerve and a small easily followed lateralis component and no recognizable neural crest component, the nerve is apparently aside from the lateralis component exclusively gustatory.

The differentiation of structures derived from neural crest or from ectoderm as compared with those derived from endoderm is relatively easy in the urodeles owing to differences in size of cells and in the number and size of yolk granules. Endoderm cells and structures derived from endoderm consist of large cells and contain numerous large yolk granules which stained with Delafield and orange G give a light yellow field with few nuclei. If stained with iron alum, such a field is dense black. Cells and structures derived from ectoderm and neural crest consist of smaller cells with small yolk granules presenting a darker denser mass when stained with Delafield and orange G. The distinction based on yolk granules exists even in mesenchyme, so that the two types of cells can be recognized even where they mingle in early embryos.

One of the striking features of the history of placodes in urodeles is the fact that the placodes grow as solid masses of ectoderm and become detached from the ectoderm as masses which are relatively easy to follow during the migration medially and during the time the placode rests on the endoderm of the pharynx. The distinction between ectodermal and endodermal derivatives persists until the absorption of yolk granules occurs, which is far beyond stages involved in the present problem.

MATERIAL.

The material consists of stages 26 to 45 of *Amblystoma jeffersonianum.* Sections were cut transversely 10 micra thick, stained in Delafield's hematoxylin and counterstained in orange G.

TABLE SHOWING AGE AND AGE INCREMENT OF STAGES INVOLVING EPIBRANCHIAL PLACODE IX.

No. of series	26	27	28	29	30	31	32	33	34	35
Age in hours	238	243	249	255	261	267	273	280	287½	292
Increment	5 h	5 h	6 h	6 h	6 h	6 h	6 h	7 h	7½ h	4½ h

No. of series	36	37	38	39	40	41	42	43	44	45
Age in hours	297	302	308½	312	316	320	324	329	334	338
Increment	5 h	5 h	6½ h	3½ h	4 h	4 h	4 h	5 h	5 h	4 h

The history of the epibranchial placode on IX falls into two rather definite periods. The first period covers the time of growth of the placode in the nervous layer of the ectoderm and the second period the time during which the placode after completing its growth rests on the endoderm of the pharyngeal pouch during which the placode also becomes more or less completely fused with the remainder of the glossopharyngeal ganglion. This ganglion in Amblystoma has in addition to the contribution from the epibranchial placode definite contributions from the neural crest and from the dorsolateral placode.

The diagonal position of the ninth ganglion in Amblystoma makes it impossible in transverse sections to show except occasionally the fusion of the placode with the remainder of the ninth ganglion. This condition is in striking contrast to the condition of the facial ganglion. There is another rather striking difference due to the persistence of the pharyngeal pouch. The placodal portion of the IX ganglion remains in contact, resting on the dorsal surface of the pouch for a relative long period compared with the behavior of the placode of VII.

THE EARLY GROWTH PERIOD.

The early growth period is illustrated in Figures 1–4, inclusive. Figure 1, taken from series 26, is ten hours older than the first series in which the epibranchial thickening occurs, but is the earliest series in which there is marked evidence of growth as indicated by definite thickening of the primitive line. In stage 24, nine days and twelve hours after deposition, 3.75 millimeters in length and with twelve somites, the primitive thickening can be recognized,

After the epibranchial placode begins to grow there is a steady increase in its thickness and in its extension medially as a triangular solid mass. This epibranchial mass which arises from the nervous layer of the ectoderm rests with its base on the ectoderm and its apex directed medially. In the first section figured (Fig. 1, right side) it is not possible to separate the placodal thickening into epibranchial and dorsolateral because of the fusion of the two. The ventral portion of the placode on right side is epibranchial and the dorsal portion is dorsolateral and gives rise to the lateral line placode. In older stages this distinction can be made since the lateralis ganglion placode lies slightly caudal to the epibranchial placode, while the lateral line placode lies dorsal at least to the caudal portion of the epibranchial placode.

Part of the difficulty of separating the epibranchial and dorsolateral placodes is illustrated by a comparison of the right and left sides of Figure 2, where the section passes through the rostral portion of the placode on the right side and through the middle of the placode on the left side. The epibranchial placode of IX is situated well dorsal on the side of the body resulting in more or less fusion between epibranchial and dorsolateral placodes. The right side of Figure 2 illustrates also the presence of the placode rostral to the junction of the pharyngeal pouch with the ectoderm. The dorsal position of the epibranchial placode is illustrated in Figure 3. Here the section passes through the middle of the placode on both sides.

In Figure 4 the distinction between epibranchial placode and the lateral line placode is readily made. The lateral line placode lies dorsal to the epibranchial placode on the right side, while the lateralis ganglion is caudal to the level of this section. In the same figure the extension of the epibranchial placode medially is evident on right side. Both sides show the closeness of contact between the placode and the endoderm. The placode becomes detached from the nervous layer of the ectoderm except at its ventral border before any marked migration medially occurs.

During the growth period up to the time of complete detachment of the placode from the ectoderm it is evident that the placode is ectodermal in origin, that part of the placode lies rostral to the contact of the pharyngeal pouch with the ectoderm and that the whole placode lies rostral to the neural crest portion of the IX ganglion.

THE PERIOD OF CONTACT WITH ENDODERM AND FUSION WITH THE REMAINDER OF VII.

During the second period the epibranchial placode becomes detached from the lateral ectoderm except at its caudal border where the truncus glossopharyngeus arises. At this level the epibranchial placode is continuous with the ectodermal mesenchyme lying ventral to it. This contact is similar to that in similar stages of the facial placode. As illustrated in Figure 5, the junction of the placode with the pharyngeal pouch is at the lateral border of the pouch. In later stages the placode comes to rest on the dorsal border of the endodermal pouch. The placode in Figure 5 is not completely detached from the ectoderm, at least a small group of cells lies between the two and in contact with both.

Figure 6 illustrates a constant condition in the relation of the placode to the lateral border of the pharyngeal pouch. The placode bifurcates over the lateral portion of the endodermal pouch and the medial portion of the placode seems to give rise to a ramus pharyngeus while the lateral portion later sends fibers into the truncus glossopharyngeus. This bifurcation is constant in all early series, but when the seventh ganglion becomes detached from the pharynx and lies more dorsal in the body the diagonal course of the pharyngeal ramus makes it difficult to follow.

In stage 39, Figure 7, the change in condition of the placode is slight, showing only a slight detachment from the pharyngeal pouch. Figures 8 and 9 from the same embryo are presented to show the differentiation into neural crest and lateralis portions of the ganglion. The cellular contact of the lateralis portion of IX with the ectoderm illustrated in Figure 9, right side, is interesting since it seems to persist in Amblystoma from the time the placode arises from the ectoderm.

In stage 42 (Fig. 10) the placode is detached from the endoderm of pharynx, but a few sections rostral rests definitely on the endoderm and further shows the bifurcated condition mentioned above. The placodal portion of the ganglion withdraws from the endoderm from caudal to rostral.

The bifurcated condition of the rostral portion of epibranchial IX is shown in Figure 11, right side, where the origin of both ramus pharyngeus and truncus glossopharyngeus can be observed. In this stage the rostral portion of neural crest IX rests on dorsal surface of placodal IX. The age at which the epibranchial portion of IX ceases to rest on the pharyngeal pouch in contact with the endoderm varies. In a series four hours younger than stage 45 (Fig. 12) the rostral portion of IX, which is composed exclusively of cells derived from the epibranchial placode, lies well dorsal and has withdrawn completely from the pharynx. In two series four and one-half hours older than 45 (Fig. 12) the epibranchial placode touches the endoderm throughout the extent of a few cells.

Figure 12, right side, illustrates the last stage in which there is a well defined contact between the placodal ganglion and the endoderm. The placode is massive and the small group of cells resting on the dorsal surface of the placodal ganglion illustrate the plan of junction between the cells from the two sources. Either the neural crest cells shift rostral onto the dorsal surface of the placodal cells or the placode shifts caudal ventral to the neural crest cells.

SUMMARY.

The origin of the epibranchial ganglion of the glossopharyngeal nerve resembles closely that of the facial nerve. Each epibranchial placode is preceded by a primitive line which can be identified prior to the actual growth period in the formation of the placode. The growth period begins with a definite increase in the thickness of the placode which forms in the nervous layer of the ectoderm. This thickening lies in part rostral to the endodermal pharyngeal pouch and entirely rostral to the neural crest portion of IX. The epibranchial placode of IX begins its definite growth phase simultaneously with that of the dorsolateral placode which is continuous on its rostral border with the lateral line placode. The lateral line placode and the lateralis ganglion placode however have a more dorsal position than the epibranchial placode. In the earliest stages of the growth of all three structures there is some difficulty in separating them. This difficulty disappears when the three placodes assume definite histological structures.

The epibranchial placode during the growth period appears as a solid mass of cells, triangular in form with the base of the triangle resting on the ectoderm and with its apex directed medially. As the placode increases in size its medial portion

abuts against the lateral extension of the pharyngeal pouch and does not as in the case of VII come to rest at first on the dorsal border of the pharyngeal pouch. In later stages the placode loses its triangular form and consists of a rounded mass of cells which at its rostral end bifurcates over the lateral border of the pharyngeal pouch the medial arm of the ventral bifurcation seeming to give rise to a pharyngeal ramus and the lateral arm enters the truncus glossopharyngeus.

The caudal border of the epibranchial placode abuts at first against the neural crest portion of IX but in later stages there is a change in this relation and the neural crest portion of IX at its rostral border comes to rest on the dorsal border of the epibranchial portion. In still later stages the whole combination of IX withdraws dorsally and the ganglion is detached completely from the pharyngeal pouch. Since the epibranchial ganglion of IX arises entirely rostral to the neural crest the neural crest could not be considered as a stimulus to the formation of the epibranchial placode.

The differences in histological detail between ectodermal derivatives with their small cells and small yolk granules and the endodermal cells with their large size and large yolk granules leaves no doubt as to the ectodermal source of the epibranchial placode. This conclusion is further strengthened by the growth of the placode in the nervous layer of the ectoderm and by its compactness, since it is rare to find the borders of the placode irregular, and the gradual migration medially prior to its junction with the neural crest and dorsolateral portions of IX. The evidence points to the conclusion that the epibranchial placode is a ganglion forming structure, not dependent on the neural crest or even the pharyngeal pouch for stimulation and not a phylogenetically old sense organ and definitely ectodermal in origin like all other ganglia.

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ABBREVIATIONS USED.

L. P.—Lateral line placode.
E. P.—Epibranchial placode.
A. V.—Auditory vesicle.
N. C. G.—Neural crest portion of ganglion.
L. G.—Lateralis portion of IXth ganglion.
R. IX—Root of IX.
E. G.—Epibranchial portion of IXth ganglion.
G. IX—Glossopharyngeal ganglion.

DESCRIPTION OF PLATES

All figures are untouched photographs of transverse sections 10 micra thick of *Amblystoma jeffersonianum*. Sections were stained in Delafield's hematoxylin and orange G and photographed at a magnification of ×75 and reduced to ×35 for printing.

PLATE I.

Figures 1-4, inclusive, cover the growth period of the placode in the nervous layer of the ectoderm.

Fig. 1. Series 26, Section 123, right side rostral to left. Section or right side in middle of placode which is ten sections long. The caudal tip of the auditory vesicle and the root of the IX nerve on right side. Neural crest portion of IX on left side of section. Lateral line placode on dorsal surface of epibranchial placode on right side.

Fig. 2. Series 28, Section 120, right side slightly rostral to left. Left side through middle of placode. Right side through rostral portion of placode which here extends three sections rostral to the contact of pharyngeal pouch with the ectoderm and is fused on its dorsal surface with the primordium of the lateral line placode.

Fig. 3. Series 29, Section 132, right and left sides symmetrical and at the middle of the epibranchial placodes. Epibranchial placodes in Figures 1, 2, and 3 lie at same dorsoventral level as the lateralis ganglion placodes which are located more caudal. These two placodes do not appear in the same transverse section of the IXth ganglion as they do in the case of the VIIth ganglion.

Fig. 4. Series 32, Section 165, right side slightly caudal to left. Epibranchial placode on right side taken through middle of placode which is twelve sections long. Compared with Figure 3 the placode on the right side has grown medially but is still attached to ectoderm. On left side placode extends ventrally continuous with nervous layer of ectoderm. Lateral line placode appears on right side dorsal to and in contact with the epibranchial placode.

Figs. 5-12, inclusive, cover the period of contact with the endoderm and fusion with the remainder of IX.

Fig. 5. Series 35, Section 152, right side caudal to left. Epibranchial placode eight sections long. Right side through middle of placode which is detached from ectoderm except for a small group of cells still lying between placode and ectoderm. Placode closely attached to lateral border of pharyngeal pouch. Lateral line placode on right side.

Fig. 6. Series 38, Section 150, right side slightly caudal to left. Placode which is seven sections long free on right side from IX. Two sections caudal to right side placode is fused with IX. Placode on right side rests definitely on pharyngeal pouch. On left side, which is slightly rostral to right, and two sections from rostral end of placode, the placode shows the typical bifurcation of placode over the lateral border of pharyngeal pouch.

Epibranchial Ganglion in Amblystoma
F. L. Landacre

PLATE I.

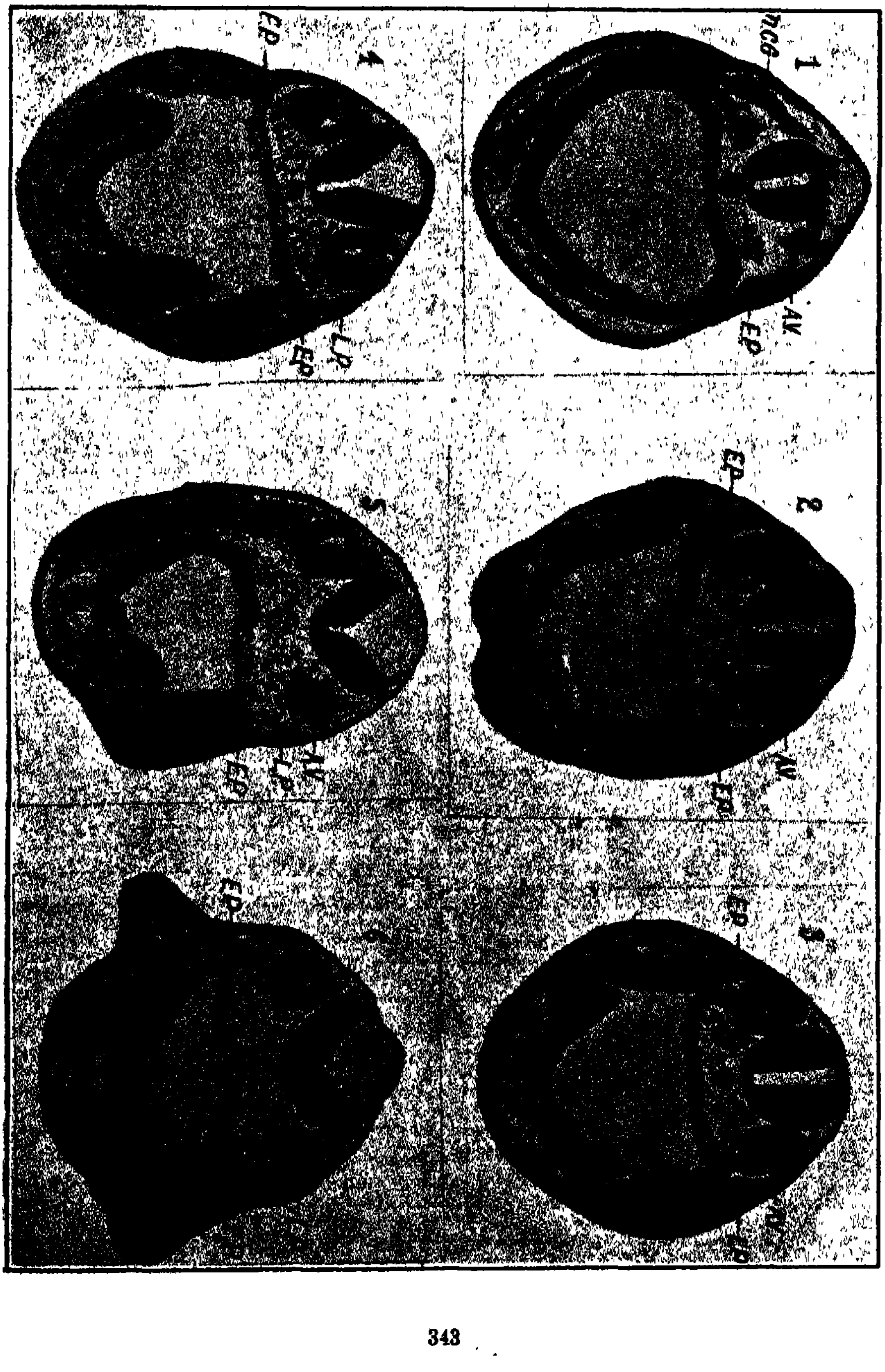


PLATE II.

Fig. 7. Series 39, Section 169, right side rostral to left. Free portion of placode on right side six sections long. Figure 7 is taken through the fifth section of placode on right side, on left side section passes through the junction of the placodal and neural crest portions of IX. The placodal portion of the ganglion lies medial to neural crest portion. The placode on right side still rests on pharyngeal pouch, but the line of contact between placode and endoderm is reduced and at the lateral border of the placode the placode is becoming detached.

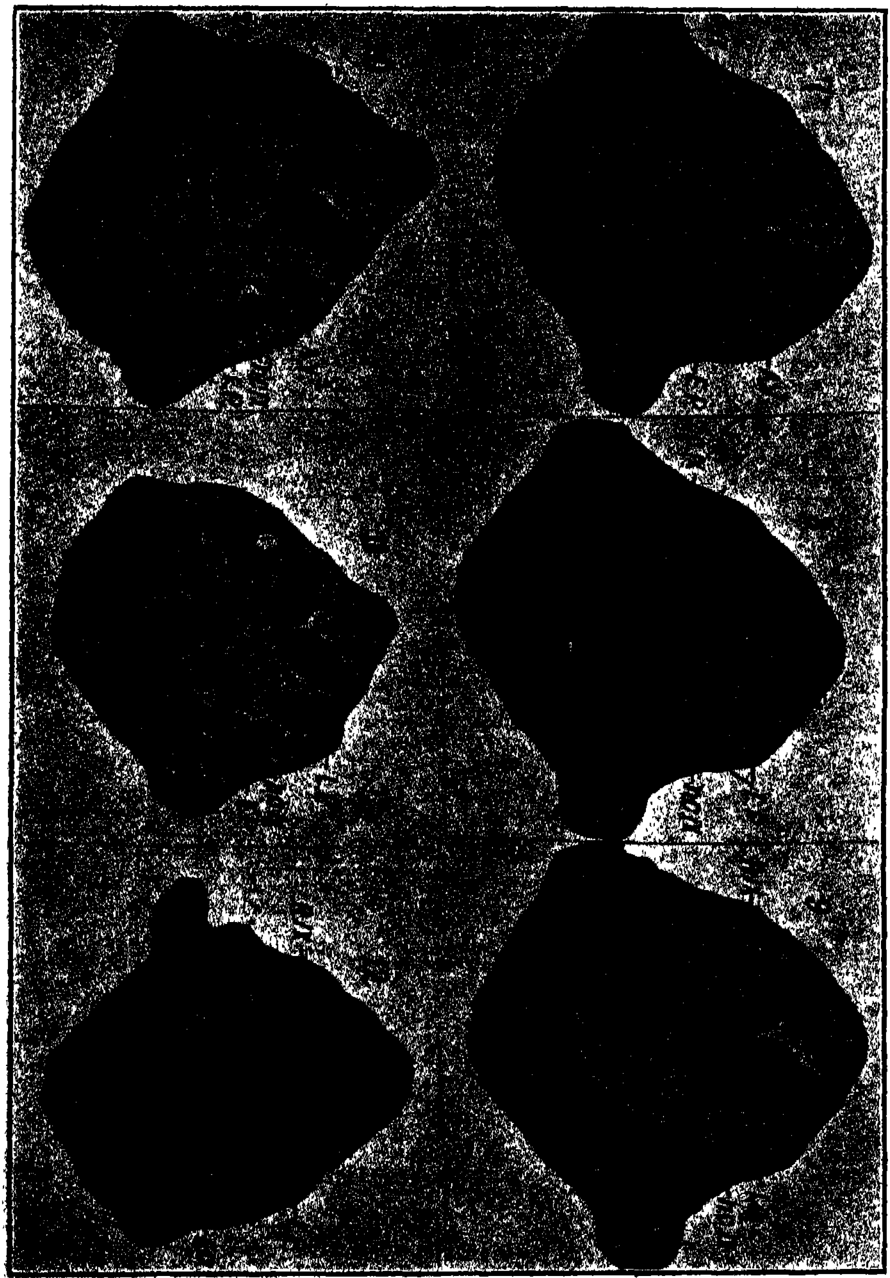
Fig. 8. Series 39, Section 175. On right side section passes through the neural crest portion of IX anterior to the junction of neural crest and epibranchial portions. On left side section passes through the root of IX and the combined neural crest situated medially and lateralis portions of IX situated laterally.

Fig. 9. Series 39, Section 178. On right side section passes through the root of IX, the lateralis ganglion of IX situated dorsally and laterally, and the neural crest portion of IX situated ventrally. The lateral portion of the ganglion consists of lateralis IX from which arise the cellular rami. The more dorsal ramus is ramus auricularis IX and the more ventral ramus is ramus supratemporalis IX. The right side of this figure illustrates a characteristic condition of the early cellular composition of lateral line nerves. On left side the section passes through the root of IX.

Fig. 10. Series 42, Section 166, right side rostral to left. Right side passes through the combined epibranchial and neural crest portions of IX, the epibranchial placode lying more ventral and lateral to the neural crest portion. The lateralis ganglion is caudal to this section. On left side of section epibranchial and neural crest portions are closely fused. On right side the close relation of the ganglion with the ectodermal mesenchyme lying ventral to the ganglion is evident. At this level the truncus glossopharyngeus arises. The detachment of the epibranchial placode from the pharyngeal pouch at this level is evident.

Fig. 11. Series 43, Section 160, right side caudal to left. IXth ganglion on right side, three sections from rostral end, consists of the epibranchial ganglion bifurcated over the pharyngeal pouch and the neural crest portion lying dorsal to epibranchial portion. The lateral portion of the epibranchial ganglion lies at the level of the truncus glossopharyngeus and the medial portion gives rise to a small nerve that is apparently the ramus pharyngeus IX. On right side only a few cells of neural crest IX rest on epibranchial IX.

Fig. 12. Series 45, Section 166, right side rostral to left. On right side the section passes one section rostral to truncus glossopharyngeus and three sections from rostral end of ganglion IX. The placodal ganglion is here very compact and readily distinguished from endoderm of pharyngeal pouch. This is the last stage where there is a constant contact between epibranchial IX and the endoderm of pharyngeal pouch.



CHARACTERISTIC EXAMPLES OF ACCUMULATIVE PROGRESSIVE EVOLUTIONARY MOVEMENTS.*

STUDIES IN DETERMINATE EVOLUTION, V.

JOHN H. SCHAFFNER.

The proper way to study evolutionary movements is to follow out the changes which occur in the activity of particular potentialities, and it is evident that a proper phyletic taxonomy can result only when the entire complex of hereditary potentialities possessed by the cell and expressed as characters in the individual is taken into consideration. Furthermore, the addition of potentialities step by step in a definite progression is one of the very striking manifestations of the evolutionary process by which comparative levels may be determined. In the present paper, studies of five prominent series of this nature are outlined. The first four deal with progressions within rather narrow limits and are confined in each case to a single genus, while the last one takes in a somewhat wider range, extending from the lowest living member of one order to the culmination species of one line of the next higher order in the phylogenetic relationship.

THE GENUS LYCOPODIUM.

There are several phyletic lines in the living species of *Lycopodium*. Taking representatives of our common northern species from the simplest to the most complex, we obtain the following progressive series:

1, *Lycopodium lucidulum;* 2, *L. alopecuroides;* 3, *L. annotinum;* 4, *L. clavatum;* 5, *L. obscurum;* 6, *L. complanatum;* 7, *L. tristachyum.*

In the lowest species, *Lycopodium lucidulum*, there is no determinate reproductive axis, the zones of sporophylls simply alternating with the zones of foliage leaves. There is no difference in the response of the various buds, all growing in one direction against the force of gravity and the direction of light. There is practically no dimorphism of the leaves and the leaves have practically no phototropic reaction, not being able to adjust themselves even out of the shade of their own stems. The growth of the stem is comparatively slow and about the same in all the buds. The dichotomous division of the buds is also comparatively slow. As one goes upward through the series of species there is almost a uniformly progressive building up of a more complex reaction system. Each new acquisition is carried through to the end of the series and is often decidedly improved. In *Lycopodium alopecuroides* a determinate condition is established with the reproductive process, which gives rise to a poorly differentiated cone. There is also some slight difference between sporophylls and leaves. A differentiated growth potentiality is introduced so that one branch of a dichotomy grows faster than the other. The slow-growing branch is the determinate reproductive branch which grows erect while the second branch of the dichotomy is a more rapidly growing, more flexible vegetative and indeterminate branch. Although the vegetative branch grows upwards it is finally brought to the ground because of its flexibility and takes root at the point of contact from which the growth and reaction continue as before.

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*Papers from the Department of Botany, The Ohio State University, No. 275.

In *Lycopodium annotinum* the differentiation between the branches of the primary dichotomies is far advanced. One branch is creeping, grows rapidly at right angles to gravity and the substratum while the other grows erect and often divides several times. All the axes of the erect branches show a definite determinate growth, some ending in cones and some stopping growth permanently in the vegetative condition, while the horizontal branch grows indefinitely. There is a very decided dimorphism between the sporophyll and foliage leaf but no peduncle is developed, the transition being directly from foliage leaf to sporophyll at the base of the cone. Thus three great properties are established which are characteristic of most of the highest plants, namely, reproductive and vegetative determinate axes and differentiation of foliage leaves and sporophylls.

In the fourth stage, represented by *Lycopodium clavatum*, efficiency of the growing system of the creeping branch is increased decidedly and the erect reproductive shoot becomes more of a unit. But the greatest advance is a disturbance established between the vegetative part and the cone, a very prominent peduncle being produced with highly specialized reduced leaves. This peduncle usually divides once giving rise to the most primitive type of inflorescence, a cluster with two flowers. The disturbance between the flower and the vegetative system below is a nearly universal characteristic of all higher plants. It is one of the important progressive movements and in *L. clavatum* we have one of its first appearances. The plant now has three distinct types of leaves without taking account of the specialization of the leaves on the creeping rhizome, due probably to a special environment in the surface of the substratum.

In *Lycopodium obscurum* (No. 5) the aerial branching system becomes much more complicated and the leaves on the determinate vegetative branches begin to show a decided reaction to light during their development. To a small extent also the branches show a definite reaction and are beginning to spread out into imperfect fan-shaped systems. In practically all lines, *L. obscurum* is an advance over *L. clavatum* except that it has not evolved a peduncle. Occasionally even in a very definite orthogenetic series a certain member may retain a primitive condition while most of its other important characters are evolving in a regular forward progression.

All of the progressive movements and complexities so far established in the series are carried forward in *Lycopodium complanatum*. The rhizome is very long and has a rapid growth; the branching system of the erect stem is decidedly more complex; and the dichotomy in the peduncle is increased so that each peduncle usually bears from four to eight cones. The determinate vegetative branches are decidedly flattened and dorsiventral with differentiated upper and lower surfaces and form definite fan-shaped systems spread out to the light because of the acquirement of a complex reaction, responding to light and gravity in a definitely correlated manner. The leaves on the flat branchlets are of three types; the two lateral rows are broad and alike, while the upper and lower rows are narrow and also differ from each other. This development of flattened fan-like systems of branches is repeated many times and becomes especially prominent in certain groups of conifers. Species with fan-like branches are especially abundant in *Selaginella* and *Thuja*. The progression in the reaction system to gravity and light and also in the morphological expression is very evident in this series. In *L. lucidulum* there is but one reaction for all buds; in *L. alopecuroides* there are two reactions but they are not very perfectly differentiated;

in *L. annotinum* there are two definite reactions; in *L. obscurum* there are three; and in *L. complanatum* there are also three reactions, but they are more complete or extreme than in *L. obscurum*.

Lycopodium tristachyum is a little more extremely developed along the same lines as *L. complanatum*, except that the branchlets appear less flattened because they are narrower and the leaves more reduced. There is greater branching potentiality in the aerial shoots so the peduncles commonly have 8 or more cones instead of 4–6. The vegetative branches composing the fans are also more numerous and the horizontal stems are extensively creeping, 1–4 in. below the surface. There are seven distinct types of leaves on the plant the same as on *L. complanatum*.

Lycopodium complanatum and *L. tristachyum* compared with *L. lucidulum* show, among other characters which might be considered, the following ten important lines of cumulative, evolutionary advancement:

1. From indeterminate growth for all axes to determinate growth of the reproductive branches in addition to the indeterminate growth of the creeping axis.
2. From no definite dimorphism of the foliage leaves and sporophylls to a decided dimorphism with highly differentiated sporophylls.
3. The origin of definite determinate growth in the vegetative aerial branches.
4. Evolution to a dorsiventral shoot system, involving leaves and stems and giving a definite reaction to light, the upper side being darker green than the lower side.
5. Differentiation of the leaves has taken place, so that, counting the sporophylls, there are seven distinct types of leaves instead of the uniform type of *L. lucidulum*.
6. Development of a very rapidly growing and extensive rhizome.
7. Differentiation of response to gravity and light has been introduced so that at each primary dichotomy of the indeterminate horizontal axis one of the twin buds grows at right angles to the force of gravity and the other grows upward against it.
8. Development of a branching system in the reproductive shoot giving rise to an inflorescence.
9. Development of a peculiar type of hereditary expression between the flower and the vegetative axis below, giving rise to a prominent peduncle.
10. Great development and improvement in the vegetative branching system through the presence of a more rapid dichotomy of the growing bud of the aerial shoot.

The development of flowers, differentiated sporophylls, peduncles, and inflorescences, through branching activity expressed in the reproductive shoot, are all decidedly characteristic of the higher plants. The change from a simple vegetative geotropic response to a complex reaction to gravity of various vegetative points of the stem system is also repeated in a multitude of cases in the higher plants. The reaction is to a condition universally possible to all and since only a part took the step, the cause is not to be looked for in the presence of the ground environment beneath nor to the influence of gravity, which acts equally all over the earth, but in the ultimate constitution of the structure of the living systems involved.

THE GENUS EQUISETUM.

The genus *Equisetum* represents a survival of a single small group of a phylum that in ancient geological times had an abundant and complex development. *Equisetum* is both primitive and at the same time highly specialized. The living species form a system of quite closely related groups which show a remarkably consistent progression from the lowest stage to the very highest. Disregarding the segregative characters and various repetitions which appear at the culmination points of the six main sections into which the genus falls, the complete progressive accumulation of the important characters can be represented by the following series:

1, *Equisetum giganteum;* 2, *E. myriochaetum;* 3, *E. ramosissimum;* 4, *E. laevigatum;* 5, *E. fluviatile;* 6, *E. silvaticum;* 7, *E. arvense.*

Equisetum giganteum is a plant with a long-lived aerial shoot with numerous whorls of branches, with a large, sessile, apiculate, green terminal cone and with numerous small cones on the branches. The ring or calyx at the base of the cone bears sporangia on the upper side. The plant is said to attain a length of 20 ft. or more. In *E. myriochaetum* there is a considerable reduction in size but there are still abundant whorls of branches. *E. ramosissimum* is still more reduced and the branch whorls are rather sporadic. In *E. laevigatum* the branches are very sporadic and often entirely absent. The next species on the list, *E. fluviatile*, belongs to a different line and connects more closely with *E. giganteum* but is in most respects on a much higher level than *E. laevigatum*. *E. fluviatile* has whorls of branches and bands of stomata like *E. giganteum*. It has advanced very decidedly from the primitive condition represented by *E. giganteum*. The aerial stem is annual instead of perennial, the cone is without a point because of a more prompt determination of the floral axis, the calyx is usually entirely sterile, and there is a rather definite beginning of the evolution of a peduncle. The fertile and sterile shoots show no dimorphism except that the one has a cone and the other has none. In *E. silvaticum*, aside from its specific specializations, there are several important advances. The fertile and sterile shoots are decidedly dimorphic. The fertile shoot has little chlorophyll at first and no whorls of branches and the peduncle is quite prominent. Later whorls of green branches develop on the fertile stem and only the cone and its peduncle wither after the spores are shed. The cones are differentiated underground at an early stage and not delayed until after the aerial stems have developed as in the preceding species. In *E. arvense* the progression is carried to the extreme. The fertile and sterile shoots are decidedly dimorphic. The fertile shoot develops no branches and has little or no chlorophyll. The differentiation of the flower is begun underground at the inception of the shoot during the previous season. The entire fertile stem withers in a few days after it comes out of the ground when the spores are shed. The peduncle is very highly developed and the whorl branches are solid and have but three or four ridges on the internodes.

It is a remarkable fact that in so far as the morphology has been worked out the evolution of the gametophyte moves forward consistently in the same general direction. The gametophytes are comparatively large in *E. laevigatum* and *E. debile* and are hermaphroditic while in *E. arvense* they are comparatively small and are normally unisexual. In the hermaphroditic species the archegonia are devloped first and later the antheridia. There are sometimes as many as 200 archegonia on a single hermaphroditic plant. The embryology also indicates that the first four species of the given series are the more primitive and nearer the eusporangiate ferns than the last three.

Comparing the sporophytes of the last species with the first, we note the following additions to the hereditary potentialities which represent the progressive evolutionary movements that have taken place to bring *E. arvense* to its high level of complexity:

1. The aerial shoot evolves from the perennial to the annual condition. This same movement appears in two other lines of Equisetum and has taken place in large numbers of the higher groups of plants.
2. The fertile shoot changes from an abundantly branched condition to a specialized stem without branches.
3. The fertile shoot including the flower, has lost nearly all of its chlorophyll and is brown in color. This loss of chlorophyll is a general evolutionary movement in all the higher flowers.
4. The fertile shoot evolves from a long-lived system to a very short-lived system, withering soon after emerging from the ground.
5. The fertile shoot is developed entirely underground, complete for spore dispersal and differentiated from the beginning.
6. The cones are more definitely determinate and do not have a vegetative point. This progression toward greater promptness in determination of the reproductive axis is a universal trend in all the higher plants.
7. There is a distinct reduction in the number of sporophylls because of the earlier determination and this movement is also practically universal in floral evolution.
8. The calyx evolves from a sporangium-bearing whorl to a completely sterile structure, thus giving a definite, sterile perianth, the first to appear among the living species of vascular plants.
9. A prominent peduncle has evolved below the flower, duplicating the corresponding evolutionary movement in *Lycopodium*. The peduncle is very generally evolved in the plants above this level.
10. The fluctuation between flower and vegetative tip with the development of intermediate semi-sterile cones is quite rare while in the species on a lower level it is exceedingly common. In the higher flowering plants intermediate shoots are exceedingly rare, in fact practically non-existent.
11. The fluctuation in the length of the vegetative internodes is less common than in the lower species.
12. The aerial shoots are very much smaller and this movement is prominent in every section of the genus.
13. Proliferation, which represents a return of the reproductive axis to the most primitive condition is much less common than in species on a lower level belonging to the same general group, like *E. fluviatile* for example. The same condition holds for low types of flowers in higher subkingdoms. Proliferation is common in such genera as *Araucaria*, *Larix*, and *Rosa*, while it is absent or exceedingly rare in the highest.
14. The number of teeth and sheath segments of the branches is very definite in *E. arvense*, being three or four, while in the lower species the numbers fluctuate decidedly.
15. Cones are rarely developed on branches, even in related species where branch whorls are still present on the fertile shoots, while in *E. giganteum* and other low species branch cones are a regular feature.

THE GENUS SMILAX.

Smilax represents one of the very extremely specialized groups of the monocotyls. The greenbrier family is plainly closely related to the Convallariatæ as represented by *Polygonatum*. In fact, Smilax is apparently only a specialized branch of the same phylogenetic series. The main series of progression is well represented by the following species:

1, *Polygonatum commutatum;* 2, *Smilax ecirrhata;* 3, *S. herbacea;* 4, *S. pumila;* 5, *S. glauca;* 6, *S. hispida;* 7, *S. lanceolata.*

Polygonatum commutatum has a creeping, more or less fleshy rhizome with an annual aerial herbaceous shoot usually from 3–6 feet high with about 20 leaves, the internodes being about 1–1½ in. long except the basal one which is often 16 in. or more in length. It has bisporangiate flowers and the anthers have four microsporangia. There are no tendrils. In most other general characters it is much like an herbaceous *Smilax*. Both in *Polygonatum* and *Smilax* there are two-ranked leaves which condition is a very general culmination in the monocotyls in the evolution from a three-spiral condition. In the lowest species of *Smilax*, namely, *S. ecirrhata*, the two-ranked condition is not very definite.

Now in passing from *Polygonatum commutatum* to *Smilax ecirrhata* four very important progressive changes are in evidence. The plants become diecious, the microsporangia are reduced to two in the anther, there is a slight development of woodiness in the lower part of the plant, brought about by the hardening of the pith, and a potentiality is added for developing tendrils on the petioles. The new tendril heredity is only active toward the end of the ontogeny of the aerial shoot. The tendril potentiality has been added to the previous normal leaf heredity. The old potentiality is not destroyed, but is active in the juvenile condition. The new tendril heredity is latent until the juvenile physiological gradient is passed, when the functional conditions of maturity throw it into play. In this case, therefore, there is recapitulation of the ancestral character at the beginning of the ontogeny. Very frequently the new heredity added to a system is such that it becomes active in the juvenile condition and recapitulation may then occur at the end of the ontogeny or even in the middle stage. In *S. ecirrhata*, if the plants are small, so that growth does not continue long enough, there will be no tendrils whatever even on the last leaves.

Passing over to *Smilax herbacea*, we have the same general type of plant although the tendrils usually appear somewhat earlier. The first tendrils usually appear on the 5th to 10th leaf. All the subsequent leaves will have tendrils normally. A new factor is now introduced which is destined when fully evolved to produce a most remarkable monocotyl. This is a potentiality for rapid and prolonged growth. This new potentiality causes the mature plant to elongate rapidly and thus a viny stem is developed which, because of the presence of tendrils on the leaves gives the plant a slight climbing ability. It will be noted that the tendrils were evolved in a plant which has no climbing ability otherwise. *S. herbacea* is somewhat less woody than *S. ecirrhata*.

In *Smilax pumila* the rambling factor is considerably augmented and the stem which is still terete is weak or reclining and still only about 2–6 ft. long. The woodiness of the stem is not very marked, but is nevertheless much more prominent than in the preceding species. As intimated above, the woodiness in all the species of *Smilax* is a new characteristic and is produced by the hardening of the walls of the ground tissue or pith and not by an increase of xylem in the vascular bundles. It is entirely a secondary evolutionary acquisition laid down on top of the original potentiality responsible for ordinary pith parenchyma. The petioles and tendrils of *S. pumila* are also not very woody. All of the four species considered so far have prominently elongated basal internodes, usually the first two above ground. The lowest internode is usually from 4–12 in. long and the second from 3–6 in. The internodes between the foliage leaves usually range as follows: *Polygonatum commutatum*, 1–1½ in.; *Smilax ecirrhata*, 1–2 in.; *S. herbacea*, 1–3 in.; *S. pumila*, 1–4 in.

In passing up to number 5, *Smilax glauca*, we meet the first typical greenbrier. The stem is completely woody and the woodiness extends to the petiole base and tendrils. The leaf blade is deciduous beyond this woody base. The internodes are perceptibly longer on the main axis than in the preceding species, usually being from 2½–4 in. long. The rhizome is long and slender and prickly but somewhat tuberous. The tendrils appear earlier in the ontogeny, usually on the fourth to sixth leaf. The stem has prickles which is a new evolution and these are present on most woody species. The stems are usually about 6 to 12 ft. long and definitely climbing, but still inclined to be somewhat bushy. The rambling habit is far from being completely evolved. The ultimate twigs are definitely quadrangular. Many of the woody species have these quadrangular twigs not because of any advantage or disadvantage, for similar quadrangular twigs appear in many monocotyls and dicotyls, in herbs as well as woody plants, in aquatics as well as in ordinary aerial mesophytes. The quadrangular character is frequently associated with the attainment of the two-ranked condition or opposite leaves. It represents an evolutionary progression from a radially symmetrical system to a bilateral system. Ornamental white spots are usually in evidence on the leaves of *S. glauca*. There is also a progressive reduction of the ovulary in the series. *Polygonatum* has several ovules (6–2) in each cavity; in the herbaceous species of *Smilax* there are two ovules in each cavity; while in the higher group, or woody species, there is but one ovule in each cavity. Thus the ovulary is approaching the ultimate unilocular condition.

The next evolutionary step gives a typical greenbrier in *Smilax hispida*. The rapid growth factor is greatly increased so that this liana frequently climbs up in trees 30 to 45 ft.; the internodes of the main stem are commonly 4–10 in. long. The stems are usually also very prickly. In general the progression toward an ideal liana is far advanced.

Taking *Smilax lanceolata*, or Florida Smilax, as an ideally developed liana species, several prominent orthogenetic advances are in evidence. The plant grows at an enormously rapid rate and the internodes are frequently over 1 ft. long. The plant often climbs up 70 to 80 ft. to the top of tall trees, and has scattered prickles on the main stem, although none on the branchlets. Only the first or second leaves are usually without tendrils. The tendrils appear in successively earlier stages of the ontogeny as one passes through the *Smilax* series. The leaves are usually decidedly narrowed and have only 3–5 nerves (mostly 3) instead of the 15–21 nerves present in *Polygonatum* or the 5–13 nerves present in the species from Nos. 2–6. The leaves have become persistent, which might, of course, be a condition handed down from the ancestral type in the series. In the closely related *S. laurifolia*, the fruit ripens only the second year. The underground system consists of large tuberous stems suggesting very large potatoes. These tubers also represent the extreme when compared with the preceding species, beginning with the creeping rhizomes of *Polygonatum*.

When one considers carefully the changes which take place step by step in this series of seven species, he discovers a most remarkable building up process which shows how evolution progresses by the addition of new character potentialities on top of the old and by the orthogenetic perfection of the characters when they are once added. All of these plants are dwellers in the forest and thicket. The series is not to be explained on any assumption of impelling environments nor by any notions of special utility, although a Lamarckian might here actually find a special utility in the base of the petiole and the tendrils. But as is evident from the analysis given above, the tendrils and woodiness began to appear before there was any use for them and the beginning of the stretch habit appeared before there was any real climbing to be done. As to the leaf forming the abscission at the outer end of the petiole instead of at the base, which might seem like a plain case of survival through advantage to a believer in Darwinism, the same thing occurs in species of *Rubus* and other plants where no tendrils are present and where no stem is to be held up to a support. The teleological explanation of quadrangular twigs, prickly stems, fruit delaying its maturity to the second year, and especially the prickles on the underground rhizomes should certainly strain the credulity of even the most credulous to the breaking point.

THE GENUS VIOLA.

The violets show a very beautiful orthogenetic movement from the bottom to the top of the series. The following species will represent the main progression:

1, *Crocanthemum canadense;* 2, *Cubelium concolor;* 3, *Viola canadensis;* 4, *V. odorata;* 5, *V. pallens;* 6, *V. papilionacea;* 7, *V. palmata;* 8, *V. pedatifida.*

The ancestral type of the violet family may in a general way be represented by *Crocanthemum canadensc* which has erect stems, sometimes 2 ft. high, short-petioled leaves, only slightly zygomorphic flowers, and numerous stamens. It has both showy petaliferous flowers and apetalous cleistogamous ones. The cleistogamous flowers are, of course, a specialization which might not be present in the lower violets.

In *Cubelium concolor* the more typical violet characters are already evolved. Although the stem is still erect with short-petioled leaves and short-peduncled flowers, the flowers are decidedly zygomorphic and the stamens are reduced to five.

In *Viola canadensis* the generic characters of *Viola* have been fully attained and the sepals are highly specialized, being more or less prolonged posteriorly. This character is still missing in *Cubelium.* The two lower stamens are also specialized, being distinctly spurred. The flowers are thus much more zygomorphic both externally and internally. Two other very characteristic violet characters are evolved to a moderate degree. Although the plant still has an erect aerial stem, the petioles and peduncles show a distinct tendency to elongate. This movement will end in a very extreme condition in the higher geophilous violets. It is to be noted again that the evolutionary movement begins before there is any need of it and before the plants show any definite tendency toward geophily. In this species petaliferous flowers are still often produced throughout the summer.

The group of violets to which *Viola odorata* belongs shows a strong movement toward the development of the geophilous condition in that there are long and slender leafy stolons produced above ground. The most remarkable potentiality added is the dimorphic production of flowers. This plant as well as most of the species on a higher level in the same phyletic series has both the ordinary showy flowers and apetalous cleistogamous flowers which have only two functional stamens.

In *Viola pallens* the orthogenetic movement has advanced further and the plant has long slender rhizomes and in addition slender creeping stolons.

Viola papilionacea represents a typical blue violet. The stem has become a thick, fleshy rhizome without aerial runners; the petioles and peduncles of the showy flowers are exceedingly long while the peduncles of the cleistogamous flowers are rather short; the showy flowers are decidedly zygomorphic, with three distinct types of petals.

In *Viola palmata* the rhizome is more extreme and the leaves are palmately 5–11-lobed, while in *V. pedatifida* the extreme of the series is reached in a plant with short erect rhizomes and palmately multifid leaves with very narrow segments.

The evolution of cleistogamous flowers in a series which has only showy insect pollinated flowers at the lower levels shows how incorrect the older hypotheses of evolution, like use and disuse and natural selection, were; for these higher violets all produce showy flowers which are extensively visited by insects but which produce little or no seed. During the summer period the cleistogamous flowers are developed in great abundance and on the same individuals and produce large quantities of seed from which the species is abundantly propagated. This development of cleistogamous and sometimes parthenogenetic flowers at the ends of many evolutionary series of Anthophyta of both entomophilous and anemophilous plants plainly indicates that the libraries of books and articles written to prove that the showiness of the flower was evolved to attract insects to insure cross pollination are to be considered largely in the same light as our mother goose fairy-stories. Nectar glands and fragrant odors are associated with some sporophylls of ferns long before there were any flowers and before there was any pollen to be carried, and attractiveness of beautiful colors and even zygomorphy are frequently in evidence in the lower wind pollinated series, while many of the entomophilous series end in exceedingly inconspicuous types.

A CONIFER SERIES.

There are many exceedingly interesting progressive series in the Coniferæ. The following one will illustrate a progressive building up of a very complex hereditary system from a comparatively simple one, the series running through two families and a number of genera.

1, *Araucaria imbricata;* 2, *Cunninghamia sinensis;* 3, *Sequoia sempervirens;* 4, *Pseudotsuga mucronata;* 5, *Picea abies;* 6, *Cedrus lebani;* 7, *Pinus strobus;* 8, *Pinus serotina;* 9, *Pinus radiata;* 10, *Pinus muricata.*

Araucaria imbricata is a very primitive type of conifer. It has a rhythmical development of branches on the main stem and the foliage leaves are close-set in spirals. The leaves of the main stem have no developed buds in their axils except at certain intervals and are all of the same general type. There are no bud-scale leaves, the resting period being simply marked off by a zone of shorter, smaller green leaves. The leaves have no phototropic ability. The whorl branches also have sporadic development of buds in the leaf axils and these develop into prominent secondary branches which are a sort of dwarf branch. There are no internodes on the plant. The staminate and carpellate cones terminate leafy branches and the sporophylls are very leaf-like.

In passing up to *Cunninghamia sinensis* there is evident a considerable narrowing of the leaves and the leaves also show a phototropic reaction. There is a slight beginning of a resting bud with specialized bud scales. The staminate cones are in clusters and the carpellate cones also show a tendency to be clustered although they are often solitary at the end of a leafy shoot. There is a considerable difference between sporophylls, and foliage leaves. The carpels, however, still show a distinct midrib and other leaf characters.

Sequoia sempervirens shows an increase in the evolution of the resting bud and bud scales. The leaves are linear and react definitely to light and the carpels are highly specialized and thickened. These three species form a suitable, primitive background for the pine series proper.

In *Pseudotsuga mucronata* the winter bud is well evolved and shows dry scale leaves. The carpels have large carpellate bracts and the thickening takes place in a different manner from that in *Sequoia*, the lower part of the carpel back of the seeds being developed into a distinct structure, the ovuliferous scale. The tree, therefore, has four distinct kinds of leaves, instead of three as in *Araucaria imbricata*. The foliage leaves are linear, being evolved to the same condition as in *Sequoia sempervirens*. *Pseudotsuga* along with the remaining genera of Pinaceæ has winged pollen in contrast to the lower Taxodiaceæ and Araucariales.

In *Picea abies* the leaves have become prismatic but still show a slight reaction to light in bending away from under the twig. The carpellate bracts have been reduced and are hidden beneath the ovuliferous scales which are much as in *Pseudotsuga mucronata*. There are sporadic buds which develop into small branches in numerous leaf axils between the main branch whorls and the branches also show sporadic bud and branch development in some leaf axils. The plant is thus definitely evolving to a less simple, less symmetrical system.

Cedrus libani shows a considerable evolutionary advance in the acquisition of sporadic dwarf branches which, however, have indefinite growth. The foliage leaves on the dwarf branches are beginning to elongate and are in the first stages of the evolution of needle leaves. The scale leaves of the dwarf branches are somewhat different from those of the long branches. The leaves of the long branches are also different from the foliage leaves of the dwarf branches. The ovuliferous scales, although of the same general type as in *Pseudotsuga* and *Picea*, are more thickened and woody. The cedar thus has two kinds of foliage leaves, two kinds of bud scale leaves and two kinds of sporophylls.

Now, passing over to the genus Pinus, several important new characters are again added. In *Pinus strobus* the ovuliferous scale shows three new characteristics which are not present in *Pseudotsuga.* The scale is elongated, is showing considerable woodiness and has a peculiar ornamental tip. The leaves on the main axis and long branches are changed to dry scales and each one develops a bud which gives rise to a dwarf branch. These dwarf branches are determinate in growth and after developing bud scale leaves and five foliage leaves are completely arrested in further development. Thus vegetative determinateness is again evolved. After several years each dwarf branch is self-pruned by the development of an abscission layer. The foliage leaves are longer and more definitely needles than in the cedars and larches. The white pine, therefore, has developed an enormous efficiency for producing axillary buds when compared with *Araucaria* or *Cunninghamia.* In the next higher family beyond the pines, the Juniperaceæ, as for example *Juniperus barbadensis*, the number of buds and twigs in a comparable branch system is again enormously increased when compared with *Pinus* although bud development is sporadic and many leaf axils do not produce functional buds. *Pinus* has four kinds of mature vegetative leaves besides the two kinds of sporophylls or twice as many general types as *Araucaria imbricata.* In addition there is still a seventh kind of leaves present in the system, the special juvenile leaves of the seedling to say nothing of a distinct kind of cotyledons. The basal elongation of the needle leaves becomes very pronounced in some species of pines. In the white pine there is a peduncle on the subterminal carpellate cones, but this is a specialization which is not continued in the yellow pine group, represented by the last three species of the series given, although these have a very marked modification of the lower carpels. The cones ripen promptly in the summer of the second season. The pollen, of course, has the highly specialized two wings or sack-like appendages.

Pinus serotina shows a decided specialization in developing "wrapper" scale leaves on the dwarf branches. The foliage leaves are reduced to three on the dwarf branch and are more extremely evolved as elongated, rigid needle-leaves. The ovuliferous scales are more elongated, much more woody, and have a much more extreme, ornamental apex than in *Pinus strobus*. The cones are lateral showing the beginning of irregular branch development as in *Picea*. There is also a very decided shortening of the base of the carpellate floral axis, giving rise to a wide sterile zone of carpels. This is again a first step in the evolution of a perianth. The terminal carpels also show a different development. Thus there are three general types of carpels and three rather distinct regions of the cone to be definitely recognized. These differences are less pronounced in the lower members of the series.

In *Pinus radiata* a striking new property is added, resulting in a decided zygomorphy of the carpellate cone. Zygomorphy is a characteristic of nearly all the highest types of flowers of the Anthophyta. The ovuliferous scales are much larger on the outer side than on the inner and the tips have prominent rounded protuberances. Thus there are really four general types of carpels which, of course, intergrade with each other. With the five kinds of vegetative leaves and counting but one type of stamens, this pine has ten kinds of leaves besides the cotyledons. This certainly indicates a decided evolutionary advance in complexity when compared with the three types present in *Araucaria imbricata*, the two types in some of the higher ferns, or the single type present in many of the lower ferns, where no morphological difference is to be observed between sporophyll and foliage leaf except the presence of sporangia on the former.

Pinus muricata has much the same general characteristics as *P. radiata* but the ovuliferous scales are more elaborated. The knob below the apex is flattened and armed with a stiff flattened spine. The cones are decidedly zygomorphic as in *P. radiata*. There are but two leaves on the dwarf branches, which is the usual limit to determinateness in the higher pines except in one species of nut pine in which there is mostly but a single leaf on a dwarf branch. The higher pines are commonly characterized by irregular development of their crowns. This is especially due to the intercalary development of long branches between the rhythmical branch whorls. In some species, as for example *Pinus contorta*, the old crowns are sometimes grotesquely irregular in contrast to the regular rhythmical symmetry of the lower white pines or the remarkable, repetitive symmetry of an araucarian.

In a tree fern there is normally but one terminal bud which gives a single type of morphological reaction; in *Araucaria imbricata* there are four kinds of stem bud reactions, the terminal bud, the primary and secondary branch buds, the carpellate cone bud, and the staminate cone bud. There is very little difference in the reaction of the main stem bud and the branch buds, but the former differentiates a radially symmetrical branch system while the latter differentiates a more or less dorsivential sytem which becomes extremely fixed so that when grown as a cutting it gives rise to an unsymmetrical tree. In *Pseudotsuga* there is the same general difference of four types of bud reaction, but the difference between the terminal stem bud reaction and the lateral twig is very much greater. In *Pinus* there are in general five types of stem bud reactions, the terminal stem bud, the main and lateral branch buds, the dwarf branch buds, the carpellate cone bud, and the staminate cone bud. Thus the genus *Pinus* again shows an extremely complex reaction system in its buds and plainly stands at the end of its phyletic series in this respect also.

It is truly astonishing that in this conifer series not only the general external organography and morphology show this orthogenetic accumulation of a more and more complex hereditary system but that there are several lines of minute characteristics which went through a closely parallel movement at the same time and in the same direction. Thus the lower gymnosperms, like *Cycas* and *Ginkgo*, have two cotyledons and the same number is present in *Araucaria*, in *Cunninghamia*, and in *Sequoia sempervirens*, while in *Sequoia washingtoniana* there are three to six and in the various species of *Pinus* the number range from five to fifteen. Thus the complexity of cotyledon development has kept step with the evolution of the general complexity of the pines. In the lower Ptenophyta which presumably represent the mother phylum of the Strobilophyta there is a single embryonic leaf. The parallel series or order of Taxales also evolved polycotyledony but not to so extreme a condition as the Pinales. This development of many cotyledons is a derived condition involving the determination of correlation centers in the ring of tissue surrounding the terminal bud of the embryo. There is much variation in the definiteness of the interaction and often two centers of activity do not become developed sufficiently for independent action, thus giving rise to twin cotyledons or in some cases apparently enlarged simple cotyledons with double vascular strands. Such phenomena are, of course, common in other similar structures, as the very common development of double or broad sporophylls in *Equisetum*. The development of double cotyledons and cotyledonary tubes has given rise to controversies and the development of a contrary hypothesis that the polycotyledonary condition was the original and the dicotyledonary one the derived condition. But this would go counter to all the complex progressive movements and is not to be taken seriously. There is no basis for turning evolution topsy-turvy because of a fantastic method of interpretation of abnormalities.

In Cycas and *Ginkgo* a single embryo is organized from the egg, which is the usual condition from the liverworts on up. In *Araucaria* there is also a simple embryo without a rosette at the basal end beyond the suspensor. Passing up to the Pinaceæ one finds a decided and progressive advancement toward the most extreme condition. In *Pseudotsuga* a single embryo develops from the egg and a long suspensor but apparently no rosette cells. In *Picea* and *Abies* a single embryo is developed with rosette cells beyond the base of the long suspensor cells and essentially the same condition exists in *Larix* which in general morphology represents a more advanced condition. But in *Tsuga* a new condition is introduced and the condition of cleavage polyembryony is established, four embryos developing from a single egg. *Cedrus* which in some respects is on a lower stage of evolution than *Larix* has advanced its embryogeny to the extreme condition approaching that of the pine. There is not only cleavage polyembryony but rosette embryos are also produced. The culmination of the embryonic complexity of the Pinaceæ is reached in the genus *Pinus* where the egg, through cleavage polyembryony, develops four incipient embryos at the outer end of the long suspensor and four prominent rosette embryos at the basal end. In Biota cleavage polyembryony is even much more extreme than in the pines. Thus it is seen that the embryonic evolution moves in complete harmony in the same direction and in general keeps pace with a large number of progressive characters, thus giving rise to the exceedingly complex reaction systems present in the highest pines.

The advancement in simple bilaterality of the sporophylls is also plainly in evidence in this series. In *Araucaria* there is one central seed, in *Cunninghamia* three, in *Sequoia* four to nine, while in some of the more specialized genera of Taxodiaceæ and in the Pinaceæ the number is uniformly two, evenly balanced on the two sides of the carpel.

Another interesting development is shown by the time of maturing of the carpellate cones. Primitive forms apparently all matured their cones in a single season as is the case in *Cycas*, *Pseudotsuga*, *Picea* and *Tsuga*. In *Larix* the fruiting cones also mature the first year while in *Pinus*, the culmination of the series, the cones do not ripen until the second year. In *Juniperus*, belonging to a higher related series, some species mature their cones the first year and some the second.

The progressive reduction of the male gametophyte in the conifers also parallels the other general movements. In *Araucaria*, the pollengrain shows its primitive character by developing from 20 to 44 vegetative thallus cells (prothallial cells) besides the spermatogenous, stalk, and tube cells. In *Pinus*, which stands at the top of the Pinaceæ and far above the Araucariaceæ in nearly all characteristics, two minute and evanescent vegetative thallus cells and finally spermatogenous, stalk, and tube are produced. In the Juniperaceæ, the extreme group of the Pinales, no vegetative thallus cells whatever are developed and the pollengrain usually contains only two cells. The Taxales show a higher level in male gametophyte reduction at the base than the Araucariales, as would be expected. In some species of *Podocarpus* as many as 8 vegetative thallus cells may be developed in the pollengrain, and in various other species and related genera there is a reduction, until the highest condition is attained in the Taxaceæ, where no vegetative thallus cells are produced, just as in the Juniperaceæ, but the first division gives rise directly to the spermatogenous and tube nuclei. These plants are in this respect on the same level of advancement as most of the Angiospermæ. It is remarkable that just as in the Pinales, the extreme reduction of the male gametophyte is in the Taxales also correlated with other extreme evolutionary morphological developments. The reduction of the male gametophyte is thus consistently orthogenetic in a most remarkable manner.

A study of the wood in the series also shows a remarkably consistent progression. The cycads have a multiseriate condition of the bordered pits on the tracheids and the pits are somewhat elongated. This is evidently the primitive condition for living gymnosperms. In *Araucaria* there are also two or more rows of bordered pits usually present on the radial walls of the tracheids while in *Cunninghamia* there is mostly a single row. This specialization is carried through to the highest pines and the bordered pits become very circular instead of showing the elongated condition common in *Cycas*.

In *Pseudotsuga* the wood contains a number of characteristics which indicate a lower condition than that shown in *Pinus*. In *Pinus strobus* the upper and lower walls of the few and small ray tracheids are smooth and have the radial walls of each ray parenchyma cell communicating by one or two large simple pits with each adjacent wood tracheid. In the yellow pines generally, like *Pinus muricata* or *P. virginiana*, a much more complex reaction system is in evidence. The upper and lower walls of the small and numerous ray tracheids are sculptured with ornamental reticulations and the radial walls of each ray parenchyma cell has three to six rather small simple pits communicating with each adjacent wood tracheid. Thus the evolution of the wood elements is moving in harmony with numerous other orthogenetic progressions.

Finally another most remarkable parallel movement took place in relation to resin cells and resin passages. This series was worked out by Penhallow. Resin cells occur in the more primitive conifers and are scattered in the bast; in the next stage they occur in zones and finally they are definitely segregated. Segregated resin cells may give rise to resin cysts, as are present in *Sequoia*, *Tsuga*, and *Abies*. In *Pseudotsuga*, *Picea*, and *Larix*, the continuous system of resin canals are present and show their derivation from resin cysts by the constricted walls. In *Pinus* the walls are no longer constricted and are lined by a thin-walled epithelium, except in a few types where thick-walled cells are interspersed with the thin-walled ones. This series coincides very closely with the other numerous orthogenetic movements. Only *Pseudotsuga* seems to have marched ahead a little of its expected position in this respect. The series indicates again that the Pinaceæ are a highly evolved type of conifers and that *Pinus* is the most specialized genus of the family.

In some genera of the Pinaceæ resin canals are absent from the woody tissues of the stem except in the first annual ring of vigorously growing shoots, as in *Abies*, or the resin canals may occur only traumatically. In these cases one may assume that in such a condition a new potentiality has been added which under normal conditions interferes with the expression of the character or, on the other hand, the potentiality for resin canals may have been added even after the primary phylum had been segregated into the secondary phyla as *Abies*, *Tsuga*, *Cedrus*, etc., and then never was able normally to come to expression because the inhibiting factor had been acquired previously.

When one considers all these remarkable orthogenetic movements running from *Araucaria* to *Pinus* in the same general direction, one begins to get some superficial notion of the wonderful process which was responsible for the taxonomic system as we find it in the world today. What was it that kept all of these movements marching step by step, with hardly a deviation, in a definite direction to the end? What kept the mutative processes of the hereditary potentialities in the straight and narrow path during the long course from the comparatively simple araucarians to the highly complex reaction systems of the higher yellow pines? The very thought of special utility suggests a childish question, the notion of teleological selection is quite preposterous, the idea of a direct response to environment is ridiculous. Such notions have no correspondence with the actuality. So we will finally have to get down to the study of the nature and structure of protoplasm, yes, even to a study of the dust of the earth from which it had its origin, if we are ever to even approach the immediate causes involved in the evolutionary process.

Now this inventory of the cumulative evolution of hereditary potentialities giving rise at each stage to more and more complex characters and reactions by the addition of new heredity to the old cannot be properly appreciated unless one actually studies the complete series containing the additions step by step. If this is done then one must obtain a firm conviction that the order of presentation given above is the true evolutionary order and represents the actual general trend of the evolving system. Such a study properly undertaken will plainly show that evolution is cumulative and progressive, "precept upon precept, line upon line," potentiality upon potentiality. There is, in general, nothing hap-hazard about it. It pays no special attention to conditions and environments except in so far as the environment may or may not permit survival. In the series given all the numerous changes and additions have an equal survival value in many diverse habitats. The matter of survival is not involved at all in the characters discussed. Plants with practically none of the peculiarities are to be found prospering side by side with those that have the peculiarities. Take for example the evolution of winged pollen mentioned above. This has appeared independently in entirely different conifer lines, and conifer species with winged pollen and without thrive in the same forest. All the members of the evolved series were surrounded by the same air and subject to the same winds. The wings are not at all necessary for survival. On the other hand, they do no harm. Pollination is assured whether wings are present or not.

The whole evolutionary process, described in the five examples, presents the working out of a wonderful cosmos, a system unfolding according to some fundamental principle which we have not discovered scientifically but which is nevertheless clearly and inevitably at work in bringing out the remarkable succession of potentialities in a substance, the protoplasm, which must at the beginning have been an undifferentiated system with enormous possibilities.

The present studies show that evolution has forced its way through the circumstances of environment, ever leading forward, and that new complexities and new efficiencies have been added from time to time through an evolutionary creative principle in the same way that the creative human mind adds improvements, complexities and efficiencies to its machines and mechanical devices year by year and from age to age, until the perfect and the ideal are attained at the end, whether it be an automobile, a flying machine, a compound microscope, or a radio receiving instrument. And thus it is that when we compare a dandelion with a man we find that, because of a common forward progressive and accumulative movement they are as much alike in important potentialities which they have evolved in common as they are both profoundly different from one of the primitive members of the living kingdom, for example, a nonsexual, holophytic, unicellular bacterium.

DRAINAGE CHANGES IN THE VICINITY OF LOUDONVILLE, OHIO.

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INTRODUCTION.

In a previous number of the Ohio Journal of Science[1] the writer gave reasons for believing that the preglacial drainage from Wooster was southward toward Shreve instead of eastward toward Orrville, as postulated by Todd.[2] Obviously, if the waters could not escape by a route to the eastward they must have flowed either to the south toward the Walhonding or northward toward Lake Erie. In this paper an attempt is made to find an exit for the extensive drainage system called by Dr. Todd, the Old Mohican.

The writer takes this opportunity to give credit to other workers in this area, Leverett, Hubbard, Conrey and Coffey, all of whom have made contributions to the drainage and glacial problems.

PREGLACIAL DRAINAGE.

In preglacial time a major divide extended in a northwesterly direction through Ohio, from a point in western Belmont County, through northeastern Guernsey, Tuscarawas and Holmes counties and extreme southern Ashland and Richland counties. This divide separated the drainage leading northward toward the Lake Erie basin and the drainage to the south which led westward past Buckeye Lake. The area discussed in this paper lies to the north of the above mentioned divide.

Examination of the Loudonville quadrangle reveals the existence of a broad valley which extends from Loudonville to Wooster. This valley, now followed by the Pittsburgh and Fort Wayne Division of the Pennsylvania Railroad, was occupied by a large stream in preglacial time. Todd, who called it the Old Mohican, traced it from Mansfield to Loudonville and Shreve, where its course he believed was northeastward to Wooster, from which point he assumed it extended across a broad divide to Orrville, where it presumably followed the old valley now occupied by Little Chippewa Creek, taking a northwesterly course, leaving Wayne County north of Sterling. From this location he believed its channel led northward by way of Chippewa Lake and into the valley of the West Branch of the Rocky River. The objection to this route appears to be that there is no evidence of the existence, in preglacial time, of a channel across the divide between Wooster and Orrville.[3] Therefore it is necessary to find another course by a different route. It has been suggested that the stream may have flowed south by way of the Killbuck valley into the Walhonding. But there are good reasons why this could not have been its course. The evidence appears quite convincing that the major divide, mentioned above, crosses the present course of Killbuck Creek near the town of Killbuck. This watershed was high, 1,300–1,400 feet above sea level in many places, separating the streams in the basin now occupied by the Tuscarawas and Walhonding rivers and which had its outlet to the west, from the streams which flowed northward to the Erie basin. The divide continues westward to a point south of Nashville and from there to a position west of Spellacy, extending between the tributaries of the Clear Fork, flowing northward and those flowing south into the Kokosing River. In preglacial time this divide separated a stream, now the lower Killbuck, flowing southward and another flowing northward into the large stream which occupied the valley from Wooster to Shreve. There is further evidence which seems to favor the above conclusion; the Killbuck valley narrows markedly in the direction in which the stream flows and is narrowest at the col near the village of Killbuck, where the water was forced over the divide as a result of damming by glacial action to the north. The tributaries which flow into this portion of the Killbuck, from Kauke to the col, flow into the trunk stream at an angle normal for a stream flowing north. South of the col, the tributaries of the Killbuck are normal for a stream which flowed southward in preglacial time. This part of the Killbuck widens gradually to the south, being widest where it enters the Walhonding River. It appears conclusive to the writer that the Old Mohican did not flow southward by way of the valley of the Killbuck. The drainage must necessarily have been northward from the major divide toward the Lake Erie basin. The waters could

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[1] Ver Steeg, Karl. Drainage Changes in the Vicinity of Wooster, Ohio. Ohio Journal of Science, Vol. 30, No. 5, September, 1930.

[2] Todd, J. H. Some Observations on the Preglacial Drainage of Wayne and Adjacent Counties. Ohio State Academy of Science, Special Papers, No. 3, pp. 46–67, December, 1900.

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[3] Ibid. 1, pp. 309–314.

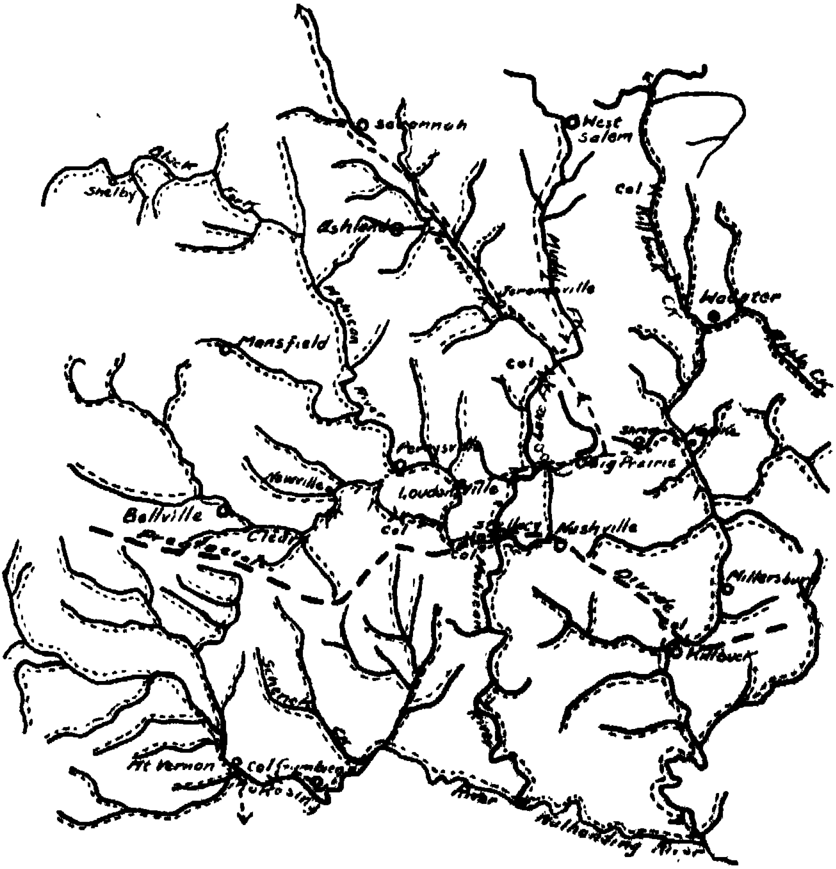

FIG. 1. Sketch showing drainage changes; dotted lines indicate the preglacial drainage.

not escape across the divide between Wooster and Orrville, nor through the upper Killbuck valley occupied by the Baltimore and Ohio Railroad; in the first instance bed rock completely shuts off the exit and in the latter case the Killbuck valley widens southward from a point between Armstrong and Overton, where a preglacial col existed, indicating that this valley was occupied by a tributary which flowed southward. The only outlet for the waters was by way of the broad valley which extends northward from Big Prairie and Custaloga. The most logical route northward is the valley of the Jerome Fork. It does not narrow to the north as the one to the east occupied by Muddy Fork which is much narrower than the Jerome Fork valley. It is evident that Muddy Fork valley in preglacial time was the site of a stream which flowed south. The greatest objection to the northward route by way of Jerome Fork valley seems to be the angle at which it meets Muddy Fork. It is such as to indicate that the two streams joined west of Blachleysville and flowed south into the Old Mohican at Custaloga. But the fact that the Muddy Fork valley has a trend contrary to what one would expect if the main stream flowed north in Jerome Fork valley is not fatal to the argument. The trunk stream appears to have flowed northwestward past Jeromesville and Savannah and from there by way of the Vermilion River valley. Because the exit of the waters is shut off everywhere except by this route, seems to the writer to be the best argument for such a course.

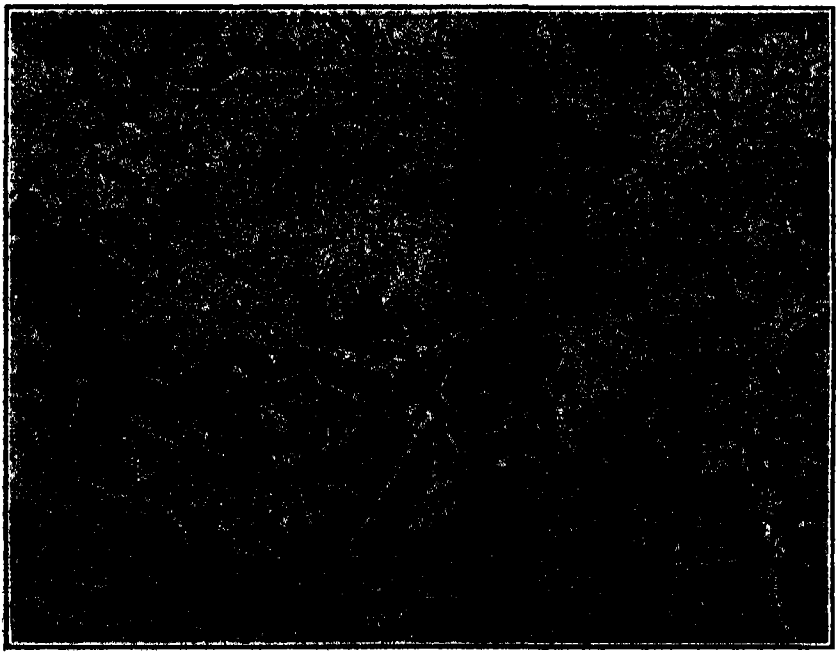

FIG. 2. Map showing the direction of the preglacial drainage, the position of the cols and the location of the Mohican Park.

Southwest of Perrysville there appears to be a broad preglacial valley about a mile long, filled with glacial drift. Doubtless this was the preglacial course of the Clear Fork of the Old Mohican. In T. 19 N. and R. 16 W., sections 8 and 17 in Mohican Park there existed a divide, which separated a tributary to the Clear Fork from another flowing eastward to what is now part of the Black Fork. This divide was higher than 1,300 feet above tide at some distance north and south of the col. An examination of the map and study in the field shows that the Clear Fork, from a point southwest of Perrysville, flows in a valley which narrows in the direction of flow, an abnormal condition, explained only by reversal as a result of glacial damming. To the east of the col, the Clear Fork valley widens perceptibly until it reaches the junction with the Black Fork, where it is more than a quarter of a mile wide.

At this point it might be well to digress for a few moments and discuss the features of the State Park. This area outlined on the map by State Forester Edmund Secrest, is one of the most interesting from the standpoint of both Geology and scenery. It is one of the recent additions to the state forest reserve, containing a purchase area of approximately 1,500 acres, of which 850 acres have already been acquired by the state. It is the opinion of the writer that no more beautiful park area exists in Ohio. There is much to remind one of the mountain regions of the west, where below timber line occur various species of coniferous trees. Hemlocks, pines and hardwoods grace the steep sides of the narrow, canyon-like valley, through which flows the Clear Fork, a clear, swiftly flowing stream. The gorge, near the col, is a fine example of a youthful valley, about 320–340 feet deep and approximately a quarter of a mile wide across the top at its narrowest point, tapering down to a width of about 200–300 feet at the bottom. Other features of youth are the steep sides with bold rock outcrops, forming prominent cliffs, typical V-shape, overlapping spurs, swiftly flowing stream with clear water and small rapids, indicating that it is still deepening its valley. On the outside of the bends are present steep, undercut slopes with characteristic cliffs and on the inside the more gently inclined slip-off slopes. Above and below the col the valley widens and flood plain scrolls make their appearance. At the point where the Clear Fork and Black Fork meet, the valley is quite wide, possessing a flood plain of considerable breadth. The same is true of the valley of the Clear Fork southwest of Perrysville, where the gorge begins. The youthful appearance of the valley is in harmony with the theory that a divide existed here in preglacial time through which has been cut the narrow, post-glacial gorge which lies within the boundaries of the park.

About a half mile or more west of Spellacy (Loudonville Quadrangle) there existed in preglacial time, a divide separating a tributary which flowed westward and another flowing eastward into the Mohican River. From the junction of the Clear Fork and Black Fork the Mohican River flows eastward in a valley which narrows until it reaches the col, west of Spellacy; to the east of the col the Mohican valley widens to the south. Lake Fork, coming from the north, flows in a valley which narrows markedly until it reaches a point about three-quarters of a mile north of its junction with the Mohican River. This position marks the preglacial divide between a short tributary to the Mohican and another flowing northward into the trunk stream which flowed from Loudonville to Big Prairie and northward. The upper Lake Fork occupies, in part of its course, what appears to have been the valley of a tributary which flowed south into the trunk stream. At Loudonville a tributary, now part of Black Fork, flowed northward and joined the main stream. This tributary had other branches, one flowing east from the Clear Fork col and another flowing

FIG. 3. View of the Clear Fork gorge in Mohican Park.

west from the Spellacy col, and two others, Horsetail Run and Pine Run.

The reversion of drainage from north to south may have occurred during an invasion of the ice, earlier than the Illinoian. There appears to be no evidence of an earlier invasion than the Illinoian, but that fact does not exclude the possibility.

Leverett's map[4] shows the edge of the Illinoian drift extending northward parallel to the Mohican and a few miles east of it, disappearing beneath the Wisconsin drift to the west of the town of Nashville. The late Wisconsin drift border extends from a point near Newville to Loudonville, and south of Nashville to a position south of Millersburg and eastward. During the Illinoian glaciation the whole of the Mohican River and the area about Loudonville was covered by the ice. During the late Wisconsin the ice edge stood from Newville to a point south of Loudonville where the Lake Fork joins the Mohican River, indicating that the late Wisconsin ice did not cover the State Park portion of the Clear Fork gorge. There is a decided contrast in topography between the area covered by Illinoian drift and that covered by the later till; the cycle of erosion is farther advanced in the case of the former. In the State Park area there appears to be little evidence of late Wisconsin glaciation. Therefore it would seem that it was either during the Illinoian or an earlier epoch of glaciation that the drainage was here reversed. Between the two epochs there was much erosion. If the deep gorge in the park, at the col, was cut during and since Illinoian time it is not unreasonable to assume that many of our deep valleys in southeastern Ohio could be post-Illinoian in age. During the long interval between the Illinoian and Wisconsin glaciations the drift may have been removed from the preglacial valleys and further deepened by erosion. Coffey[5] in his paper remarks, "practically all the deep valleys in the northeast section of the state, and probably in other sections as well, are of interglacial or postglacial origin." Although the writer does not agree in full with this statement, it is clear that we must assign a great amount of erosion to interglacial time. If each advance of the ice caused changes in the drainage, it stands to reason that the present drainage lines may in some cases bear little or no relation to the drainage in preglacial and interglacial time.

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[4] U. S. Geol. Survey Monograph XLI, Plate XIII.

[5] Coffey, G. Ohio Journal of Science, Vol. XXX, November, 1930, p. 374.

As the ice advanced during Illinoian time or earlier, lakes were formed between the major divide to the south and the ice to the north. The water rose until it was forced over the divide located between the towns of Millersburg and Killbuck. The broad valley of the trunk stream which leads from Perrysville to Loudonville was occupied by the glacier, blocking the drainage to the north, in consequence of which the waters were forced to take a southerly route over the divides at the State Park and at Spellacy and by way of the Mohican River. During interglacial time which followed the Illinoian the valleys were in large part cleared of their drift deposits. If the reversion took place in Illinoian time or earlier, the waters of the Wisconsin glacier must have passed through Clear Creek gorge. What glacial debris (outwash) has been laid down in the gorge during Wisconsin time has been largely removed. Terraces occur in the valley of the Mohican River; their elevation appears to be about 960–980 feet above sea level. The gorge of the Mohican River, before the Wisconsin epoch, in interglacial time, may have been as deep as it is at present. This would be in accordance with what is known to be true at other localities in Ohio where evidence is sufficient to prove the excavation of deep valleys in interglacial time.

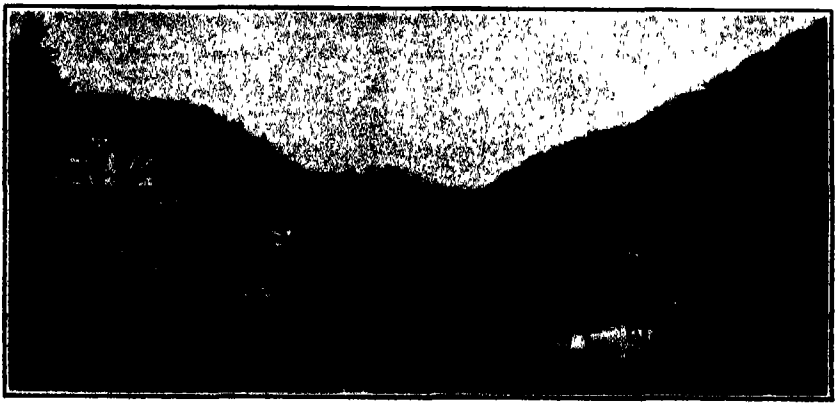

FIG. 4. View of the col, west of Spellacy.

During the retreat of the late Wisconsin ice, several elongate lakes were formed. These have been called the Finger Lakes of Ohio by Professor Hubbard,[6] of Oberlin. One of them, called

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[6] Hubbard, George D. Ancient Finger Lakes in Ohio. Amer. Jour. of Sci., Series 4, Vol. 25, 1908.

Lake Killbuck, was formed by the damming of the Killbuck valley near Holmesville by a moraine. This lake extended northward beyond Wooster and was finally drained by the lowering of the outlet located in the morainal dam. The broad flat of the Killbuck valley with its extensive swamp lands and muck deposits represents the poorly drained floor of Lake Killbuck. Another large lake produced by glacial damming during the retreat of the Wisconsin ice extended from the broad valley at Big Prairie and Custaloga to West Salem. Morainal deposits in the valley from Lakeville to Shreve formed a very effective barrier to the exit of the lake waters. The outlet of this body of water, called Lake Craigton, was by way of Lake Fork, a tributary of the Mohican River. As the late Wisconsin ice sheet receded, recessional moraines were formed. Leverett[7] shows three distinct morainic belts extending in an east-west direction in Wayne and Holmes counties. The two southernmost ones coalesce in the vicinity of Loudonville and Nashville.

CONCLUSION.

A preglacial divide existed between Millersburg and Killbuck, shutting off the escape of the waters of the Old Mohican to the south. The only possible exit for the drainage was by way of the broad valley past Jeromesville and northward past Savannah to the Vermilion River. The width and depth of the cols and the fact that the Illinoian glacier passed over a large part of the area seems to indicate that the reversion of drainage occurred during Illinoian time or possibly earlier, although no till of earlier age is present in the region. In interglacial time the Illinoian till was largely removed from the preglacial valleys, which were probably deepened by erosion. These valleys were subsequently filled with Wisconsin till and outwash deposits.

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[7] Ibid. 1, pp. 423.

THE GENUS AGALLIA—EXTERNAL CHARACTERS USED TO DISTINGUISH THE SPECIES INJURING ECONOMIC CROPS.

DWIGHT M. DeLONG AND RALPH H. DAVIDSON,
Ohio State University.

The species of Agallia are primarily pests of grasses, grains, and forage crops. They are very common and abundant upon clover, alfalfa, soy beans and similar forage crops, while meadows and pastures normally support large populations. Field workers engaged in population or disease transmission studies have found it almost impossible to distinguish and determine these species occurring on economic plants with the present treatments in literature. The only previous treatment of the Genus was by Osborn and Ball in 1898[1]. At that time they illustrated three of these species and treated eight of the species included in this discussion. Since that time Baker[2] (1898) has described two and Van Duzee[3] (1909) has described one, which are treated here. In view of the fact that at the present time there is no key dealing with all of these economic species and not more than half have previously been illustrated in any way, this brief discussion is contributed to assist field workers in recognizing them. Line drawings have been included so as to illustrate the external genital characters. The character of the male genitalia, especially the size and shape of the male plates is the best external character available for separation, although the character of the posterior margin of the last ventral segment of the female is very good in several species. In a few cases the posterior margin of the female segment is quite variable.

Examination of the internal genital characters of the male show them to be very similar in closely related species. Since other workers are examining the internal genitalia with the expectation of treating all the species of the genus and in view of the fact that the external characters are adequate for separating practically all of the economic species, the internal characters are not illustrated nor described at this time. It may be possible that through a study of these internal characters species of economic importance will be found that have not yet been described, but the internal characters examined, although differing, seem to be within the range of possible variation.

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[1] Osborn and Ball. Proc. Dav. Acad. Sci., Vol. VII, pp. 45-64. 1898.

[2] Baker. Psyche VIII, p. 199. 1898.

[3] Van Duzee. Bul. Buf. Soc. Nat. Sci. IX, p. 210. 1909.

There are two rather distinct groups of species from the standpoint of distribution. One group occupying the eastern and central states and another group found almost entirely in the western mountain states and the Pacific coast. With the exception of *sanguinolenta*, which extends into the western mountain states, these two groups scarcely overlap.

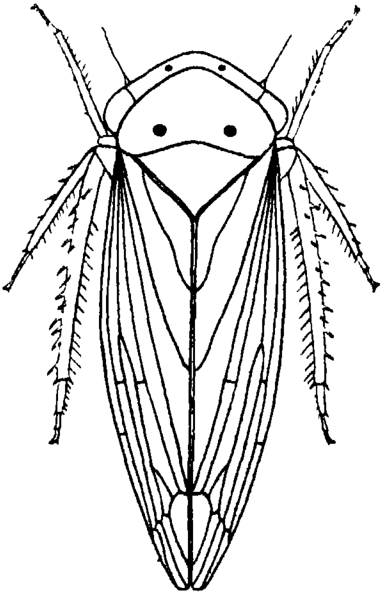


FIG. 1. *Agallia 4-punctata* Prov.
Dorsal view showing general appearance of the species of the genus.

The eastern group is composed chiefly of *sanguinolenta*, *constricta*, *4-punctata*, *novella*, *deleta* and *cinerea*. The western group is composed of *uhleri*, *californica*, *lyrata*, *bigeloviæ*, *gillettei* and partially of *sanguinolenta*. Of these species, *sanguinolenta* is the most widespread and abundant and lives upon a wide range of hosts. For many years it has been known to occur abundantly upon grains, grasses, forage crops and truck crops. It has been recognized as a pest especially of clover and alfalfa and the populations upon these crops are frequently large.

More recently rather large populations have been found on potatoes, sugar beets, beans and many other truck and field crops in varying abundance. It occurs as far west as Utah and Idaho, but its occurrence in California and other Pacific coast states is doubtful, although it has previously been recorded for California. It may be found that the insect at present called *sanguinolenta* belongs to more than one species. The writers have interpreted the large amount of material examined from the eastern and western United States as representing a quite variable species rather than two or more very closely related species. Biologic work has not been carried out to date to prove or disprove this point. Three other species in the eastern United States are frequently found with *sanguinolenta* on clover and alfalfa. These species are *novella*, *constricta*, and *4-punctata*, all of which extend as far west as Kansas and Colorado. *A. constricata* is recorded for Texas and *4-punctata* for California. There is some question concerning the authenticity of this latter record, although two specimens are at hand from Southern Idaho. Although not as abundant as *sanguinolenta*, these species have frequently been found in sufficient abundance to be of economic importance. These occur in small numbers also upon several of the truck crops and are very abundant in grasses and meadows. *A. deleta* occurs only in the southeastern United States (South Carolina, Georgia, and Florida) and may not be a species of economic importance. No economic food plants have been found or reported. *A. cinerea* is a Mississippi valley species occurring originally on native grasses and now feeding upon cultivated grasses, small grains and forage plants. It has been found as far west as Colorado and Arizona and is also recorded for California, but with a doubtful identification. Of the western species *uhleri* is most widely distributed, occurring from Iowa and Missouri to the Pacific coast, while the other species, *californica*, *lyrata* and *bigeloviæ* occur only in the Pacific coastal states and the southwest, if we may judge from available material and known records.

In California *lyrata* is found upon more crops, but usually in smaller numbers. It has been taken from 22 different crops, among which are alfalfa, sugar beets, potato, beans, carrots, and turnips. Large populations occasionally occur on sugar beets. *A. uhleri* is the most abundant species on alfalfa and the populations are quite large. It occurs on several other crops of which potato, carrots, beans and melon are the most important.

A. californica also is found abundantly upon alfalfa and occurs in greater abundance upon such crops as potato, bean, carrots, parsnip, squash and sugar beets. *A. bigeloviæ* occurs only occasionally upon economic crops.

KEY TO THE SPECIES AGALLIA ATTACKING ECONOMIC CROPS.

A. Posterior portion of pronotum with two round black spots. Large, robust or rather long and wedge-shaped.

B. Broad (almost 2 mm.) and robust; female segment almost truncate posteriorly, male plates short and narrow........................*4-punctata*

BB. Much narrower, wedge-shaped, female segment deeply emarginate or strongly produced, male plates longer and broader.

C. Posterior margin of vertex regularly curved, female segment suddenly constricted near the middle then strongly roundingly produced, male plates rather long bluntly rounded..........................*constricta*

CC. Posterior margin of vertex produced anteriorly at the middle, female segment deeply roundingly emarginate, male plates broad, bluntly rounded, fitting into a box formed by apices of pygophers.......*novella*

AA. Spots if present on anterior portion of pronotum or markings longitudinal in general form. Species usually short and robust.

D. Female segment with long pointed inwardly projecting lateral angles or with four rather prominent lobes, male plates lyrate or greatly elongate.

E. Apical half of female segment narrowed about one-fourth entire width forming inwardly set, long pointed lateral angles. Male plates long and narrow..................................*gillettei*

EE. Female segment not narrowed apically and with a four-lobed condition, male plates lyrate or elongate.

F. Female lobes conspicuous, separated by deep and rather broad incisions; male plates long and narrow..................*bigeloviæ*

FF. Female lobes rather short, separated by broad shallow indentations, male plates convexly then concavely curved to truncate tips forming lyre-like structures..........................*lyrata*

DD. Female segment sinuate or notched, but without conspicuous lobes. Male plates neither lyrate nor greatly elongate.

G. Female segment shallowly roundingly emarginate with a minute tooth at middle, male plates short but strongly narrowed to narrow, but blunt tips.....................*deleta*

GG. Female segment truncate or slightly notched at middle, male plates rather broad at apex, not strongly narrowed.

H. Female segment shallowly emarginate and slightly notched at middle, male plates most strongly produced on outer angles..*uhleri*

HH. Female segment truncate or produced and notched at middle, male plates more strongly produced on middle line.

I. Female segment truncate and rather strongly notched at middle, male plates shorter than combined width at base, apices broad and bluntly rounded..........*californica*

II. Female segment slightly produced between lateral angles, male plates longer.

J. Male plates narrowed from base to form broad, bluntly rounded tips...............................*sanguinolenta*

JJ. Male plates with outer margins almost straight. Posterior margins sloping obliquely to produced inner margins..................................*cinerea*

Agallia 4-punctata (Prov.)

Bythoscopus 4-punctata. Prov. Nat. Can. IV, p. 376, 1872.

Easily distinguished from the other eastern species by the broader more robust form and the genitalia. Length, 4 mm. Last ventral segment of female with posterior margin shallowly concavely rounded. Male valve large, broad. Plates rather short and broad, triangular, apices rather blunt. Plates slightly longer than combined width at base.

Known to occur rather generally throughout the eastern United States and recorded for Iowa, Kansas, Nebraska, Arkansas, Colorado and California. In addition two specimens are at hand collected in southern Idaho during the summer of 1930. If it occurs in California the species is apparently very scarce.

Agallia constricta V. D.

Agallia constricta V. D. Can. Ent. XXVI, p. 90, 1894.

Resembling *novella* in form and appearance, but without the intermittent dark and light markings along the sutural line. Length, 3.5–4 mm.

Female last ventral segment long, sides almost parallel margined, abruptly constricted at about half its length. The median line carinate and the posterior margin strongly produced and obtusely rounded. Male valve about twice as broad as long, plates long and narrow, slightly constricted about middle then again widening and produced to the rounded tips.

Ranking second in abundance to *sanguinolenta* in the eastern United States. Also recorded for Kansas, Missouri, and eastern Texas.

Agallia novella (Say).

Jassus novella Say. Jl. Acad. Nat. Sci. Phila. VI, p. 309, 1831.

Resembling *constricta* in size and general form, but easily distinguished from it by the elevated and anteriorly produced posterior margin of the vertex and the dark interruptions on the sutural line of the wings. Length, 3.75 mm.

Female last ventral segment with lateral angles long, well produced, posterior margin roundedly excavated from the lateral angles more than half way to the base. Male valve short, truncated, plates long, rather blunt at tips. Pygophers rather large, convexly inflated, forming an almost square opening posteriorly into which the plates fit like a lid.

A common species in the eastern United States and recorded for Kansas, Missouri, Colorado and Vancouver Island.

Agallia gillettei Osb. and Ball.

Agallia gillettei Osb and Ball. Proc Dav. Acad. Sci. VII, p. 60, 1898.

Usually narrower than *sanguinolenta*. Length, 2.75-3 mm.

Female last ventral segment narrowed about one-fourth the width of posterior half, forming prominent, rather pointed posterior angles. Between these the posterior margin is excavated by three rather abrupt, successive steps. The median notch at the apex reaches over half way to the base of the segment. Male valve twice wider than long, plates almost three times as long as valve, margins rolled up, giving them a cylindrical appearance and which causes them to appear narrow. The ends of the plates upturned.

Although *gillettei* is usually not of importance economically, it occurs through the southwest on native vegetation. It is interesting to note that specimens were collected in Florida on Sanibel Island, in April, 1921, by the senior author. This adds greatly to the known range of this species.

Agallia bigeloviæ Bak.

Agallia bigeloviæ Baker. Psyche VII, Suppl. 1, p. 26, 1896.

Resembling *lyrata* in general appearance, but easily distinguished by the genitalia of both sexes. Length, 3 mm.

Last ventral segment of female short and broad, posterior margin consisting of four prominent rounding lobes, the incisions between them reaching more than half way to the base. Male valve short and narrow, plates long and narrow, slightly constricted at base and with apices laterally compressed.

Specimens have been collected in California, Colorado, New Mexico and Arizona.

Agallia lyrata Bak.

Agallia lyrata Baker. Psyche VIII, p. 199, 1898.

Form and general appearance of *sanguinolenta*, but slightly larger. Length, 3.5 mm.

Female last ventral segment rather short and broad, lateral margins roundingly produced, posterior margin formed into four distinct, but rather shallow lobes. A V-shaped notch at the middle separates the two inner lobes and a shallow rounding emargination either side separates the outer from the inner lobes. Male valve short and broad, plates strongly roundedly widened at base, then concavely rounded to broad blunt apices which are upturned and slightly wider at tips. Together these give the appearance of a lyre.

Records at present are from California and Vancouver Island only.

Agallia deleta V. D.

Agallia deleta V. D. Bul. Buf. Soc. Nat Sci IX, p. 210, 1909.

General form of *sanguinolenta*, but slightly smaller and without dark markings. Length, 2.5–3 mm.

Female last ventral segment with posterior margin slightly concave with a very minute tooth at middle. Male valve rather long and broad, plates as broad as valve at base, gradually tapering to rather blunt apices.

Known only from the southeastern United States. Recorded for Florida, South Carolina, and Georgia.

Agallia uhleri V. D.

Agallia uhleri V. D. Can. Ent. XXVI, p. 91, 1894.

A little longer than *sanguinolenta* and less robust, but similar in color and general appearance. Length, 3–3.25 mm.

Female last ventral segment about three-fourths as long as basal width. Posterior margin sloping from prominent angles to form a central deep triangular notch reaching about one-third the distance to the base. Male valve short, truncate posteriorly, plates longer than combined width at base, lateral margins tapered to blunt apices which are slightly obliquely truncate, the outer angles longer than inner margins, tips usually dark margined.

A typically western species occurring from Iowa and Missouri to California.

Agallia californica Baker.

Agallia californica Baker. Psyche VIII, p. 199, 1898.

Resembling *sanguinolenta* in size and appearance, but with female segment more deeply notched and male plates shorter and more truncate. Length, 3–3.25 mm. Markings as in *sanguinolenta*.

Female last ventral segment more than twice as broad as long with a distinct notch at center extending about one-third the distance to base. Male valve very short and broad, truncate, plates a little shorter than combined width, apices truncate, outer margins rather strongly produced and not narrowed toward apex. Inner margins with a very slight tooth at apex either side of median line.

Recorded only for California.

Agallia sanguinolenta (Prov.)

Bythoscopus sanguinolenta Prov. Nat. Can. IV, p. 376, 1872.

This is the most common and widespread species of the genus and probably is of more importance economically, although there is a possibility that it may be confused with other closely related, but undescribed, species. Length, 3 mm.

Female segment somewhat variable. Usually slightly sinuate and with a weakly produced lobe either side of a shallow median notch. Male valve short, almost truncate, plates broad, truncate at apex, one-half longer than wide.

Probably the most widely distributed of all the species of the genus. It occurs abundantly throughout the eastern United States and has been recorded generally throughout the western United States to California. The identity of the species is the most important question in regard to these records of distribution.

Agallia cinerea Osb. and Ball.

Agallia cinerea Osb. and Ball. Proc. Dav. Acad. Sci. VII, p. 62, 1898.

Resembling *sanguinolenta* in size and structures, but pale cinereous in color and with distinct male genitalia. Length, 2.5 mm.

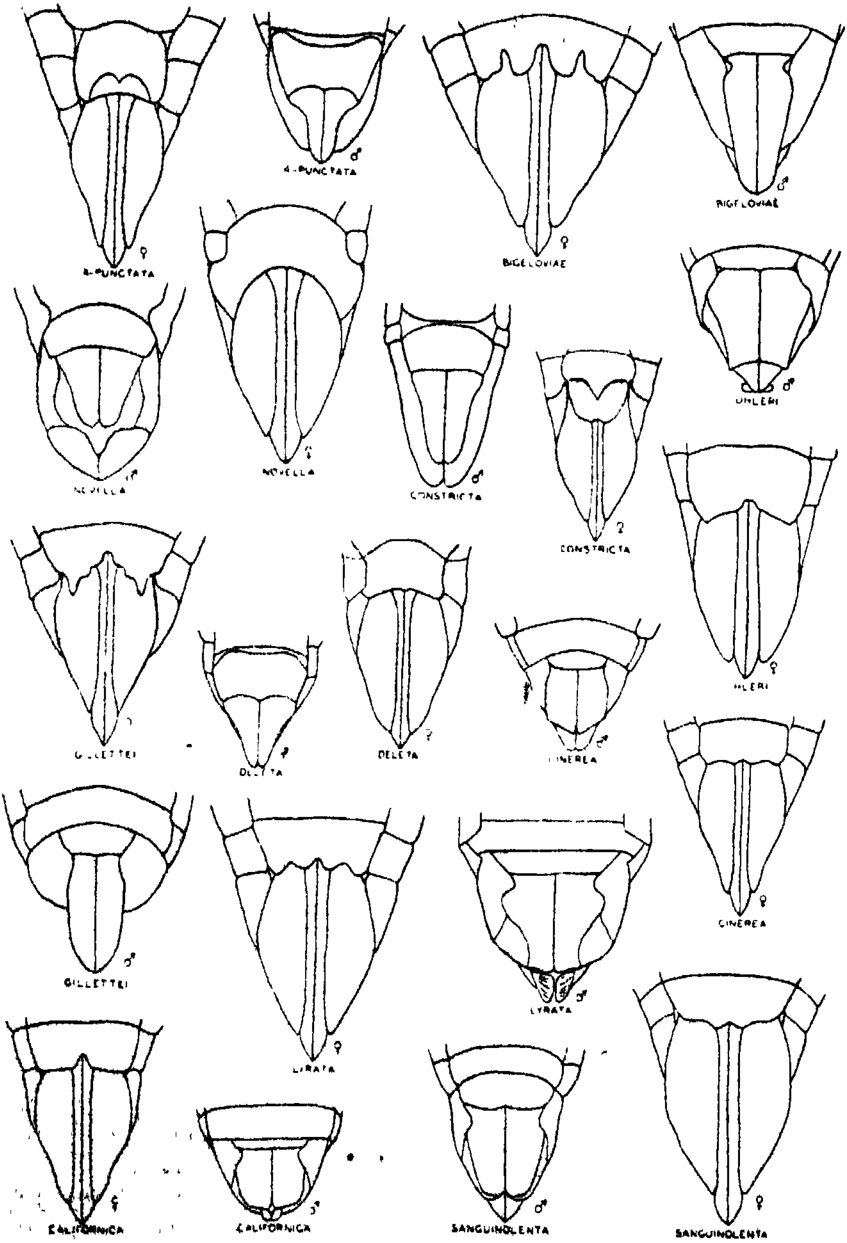
Female last ventral segment short and broad, shorter than in *sanguinolenta*. Posterior angles produced and rather prominent. Posterior margin slightly sinuated and faintly notched at middle. A transparent portion extending almost to base permits the ovipositor to be visible through the segment and causes it to appear deeply notched. Male valve short and broad, truncated or slightly concavely rounding. Plates about as long as combined width, outer margins almost straight, posterior margins sloping from rather prominent angles to inner margins which are slightly divergent and pointed.

The female genitalia are very similar to *sanguinolenta*, but the males of the two species are quite different and easily distinguished.

Chiefly a Mississippi valley species. Recorded for Tennessee, Iowa, Kansas, Colorado, Arizona, and California. If it occurs in the southwest and California it is very rare.

The Genus Agallia
Dwight M. DeLong and Ralph H. Davidson

PLATE I.



External genital characters of the species of the genus Agallia which are of economic importance.

THE ALIMENTARY CANAL OF ASAPHES MEMNONIUS HBST.

JOHN T. BIGHAM.

INTRODUCTION.

The material used in this work was collected by Dr. C. H. Kennedy at the Franz Theodore Stone Laboratory on Lake Erie, during the summer of 1929. The beetles were found feeding on watermelon rinds scattered in the forest. A considerable number of specimens were fixed in Kahle's Fixative, after which they were transferred to and preserved in 70% alcohol.

This species of click beetle is pale brown in color with paler legs. It varies in length from 13–26 mm. According to Horn it occurs from Canada to Georgia and westward to Colorado.

The author wishes to extend his thanks to Dr. Kennedy for the use of this material and also for helpful suggestions and criticisms during the progress of the work. He also wishes to acknowledge the help of Prof. J. S. Hine in determining the species.

GROSS ANATOMY OF THE DIGESTIVE TRACT.

General Discussion.

In insects the alimentary canal is divided morphologically into three primary regions on the basis of embryonic origin. The fore-intestine (stomodaeum) arises as an invagination of the ectoderm at the anterior end. The hind-intestine (proctodeum) arises as a similar posterior invagination. Connecting these two regions is the mid-intestine (mesenteron) which is derived from endodermal tissue. In correlation with the external epithelium the epithelial lining of the fore and hind intestines secretes chitin, which is found lining these two regions as a definite membrane.

The alimentary canal of *Asaphes memnonius* is of medium length as is usual in insects of phytophagus habit. In the region of the thorax it is incased by large wing and leg muscles. In other regions it is supported by tracheae and by suspensory muscles attached to the body wall.

Gross Structure of the Fore-Intestine.

In *Asaphes memnonius* the fore-intestine is very short. It extends from the mouth through the head capsule into the anterior part of the prothorax and comprises about one-thirteenth of the total length of the alimentary canal. It consists of two main divisions—*the pharynx* and *the crop.*

The pharynx begins at the mouth and comprises nearly the first half of the fore-intestine. In most specimens it appears as a narrow, nearly cylindrical tube, though in some specimens it is somewhat dilated. It has attached to it muscle strands which radiate out from it in various directions and are attached to the interior surface of the head capsule.

The crop varies considerably in size in different specimens. In some specimens there is no very distinct external line of demarcation between the pharynx and the crop. The crop continues on for some distance as a narrow tube of about the same diameter as the pharynx. Just before joining the mid-intestine it enlarges into a small bulb-like structure. In other specimens there is a constriction at the point of union of pharynx and crop and the crop begins to enlarge immediately and forms a sack two or three times as large as that in the specimens first mentioned. Since there is this variation in size, the crop apparently serves to some extent as a reservoir for food.

The Oesophageal valve marks the separation between the fore- and mid-intestine. The posterior end of the bulb-like crop disappears into the larger anterior end of the mid-intestine.

Gross Structure of the Mid-Intestine.

The mid-intestine is commonly known as the stomach. In this insect it is relatively long, extending from the anterior part of the prothorax to about the beginning of the third abdominal segment, and comprises approximately one-half the entire length of the alimentary canal.

It has a rather peculiar shape. The anterior portion lying in the prothorax and metathorax may be compared in shape to that of a club. The large end of the club is at the anterior end where it joins the fore-intestine. This enlarged end is somewhat flattened dorsoventrally, and it has shallow coeca which project forward on either side of and also dorsal to the posterior end of the crop. The number and position of these coeca seems to vary in different specimens. Following this enlarged anterior portion the stomach grows narrower and before it enters the mesothorax has become a narrow cylindrical tube. This tubular portion traverses the mesothorax. In the metathorax the stomach begins to enlarge again and forms a large pear-shaped sack which frequently occupies the larger part of the body cavity in this region. The shape of this enlarged posterior portion may be compared more exactly to that of a punching-bag used in gymnasiums. This enlarged portion extends into the second abdominal segment where it narrows abruptly, and the stomach once again becomes a tube which tapers towards its union with the hind-intestine at the pyloric valve, located at about the division between the second and third abdominal segments. The pear-shaped posterior enlargement of the stomach varies considerably in size and the tubular portions, both anterior and posterior to it, are correspondingly longer and shorter.

The surface of the stomach is covered with minute pimples which prove to be cell nests or nidi which project in part through the muscle layers of the stomach wall.

Gross Structure of the Hind-Intestine.

The hind-intestine comprises nearly one-half the total length of the tract. Its anterior limit is marked by the attachment of the malpighian tubules. It extends from this point to the anus.

The malpighian tubules are four in number and are attached at four different points around the circumference of the digestive canal, those on the two sides being slightly nearer together. They appear as long convoluted tubes which lie in the body cavity along the digestive tract. A few loops extend forward for a short distance to the pear-shaped portion of the stomach, but for the most part they run back and forth along the hind-intestine, in many places adhering to the walls of the intestine but not attached directly to it.

The pyloric valve lies just posterior to the attachment of the malpighian tubules. In this insect the pyloric valve is an unusually long structure occupying a section of the intestine which is about one-eighteenth of the total length of the hind-intestine.

The hind-intestine at the point where it joins the stomach is of the same diameter as the end of the stomach, but it immediately tapers down to form a narrow tube which makes a rather sharp bend to the right. This entire section of the intestine makes up the pyloric valve. From this point on the intestine has no very sharp divisions. The walls are very thin and the size and shape of different portions varies considerably, depending upon the amount and position of the food material contained.

At the end of the pyloric valve the intestine enlarges rather abruptly and extends cephalad to about the end of the first abdominal segment. Here it turns back again, thus forming a loop. The position in which this loop lies varies somewhat. The position shown in Fig. 1 is diagrammatic. It is usually not so wide a loop as this and often lies in such a position as to hide the pyloric valve. The portion of the intestine comprising the first half of this loop is usually comparatively narrow and the walls appear to have constrictions at more or less regular intervals. From the forward end of the loop back to the last segment of the abdomen the intestine is usually distended with food material and no constrictions are apparent. The walls of the intestine, especially in the dilated portion are very thin and are semi-transparent When examined under a binocular, white muscle strands can be seen running longitudinally along the intestinal walls. In a few of the specimens examined the intestine was empty and appeared as a tube of about the same diameter from the pyloric valve to the last segment of the abdomen.

In the last abdominal segment the intestine becomes very much narrower and extends to the anus as a very narrow tube. Fig. 1 represents a female specimen. In the male specimens which were examined this portion of the intestine did not appear to be so narrow

HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL.

Histological Structure of the Fore-Intestine.

Although divided into two divisions, pharynx and crop, the fore-intestine reveals a uniformity of histological structure throughout its length. The following layers of tissue from within outwards can be clearly demonstrated in its walls: (1) a primary intima, (2) a secondary intima, (3) an epithelium of hypodermal cells, (4) a layer of longitudinal muscles, and (5) a layer of circular muscles.

The intima is composed of chitin and is homologous with the cuticula of the body wall. It is a non-cellular, almost transparent layer and is secreted by the hypodermal epithelium. In the pharynx the two layers of the intima are fairly distinct. The primary intima stains darker but has a clear uniform structure. The secondary intima does not stain as dark and appears to have a granular structure. The intima of the pharynx is of nearly uniform thickness and presents a smooth even surface toward the lumen of the intestine. There are no spines present. In cross-sections of this region the intima is seen to be thrown up into several large folds.

In the crop the two layers of the intima are not very clearly differentiated. The division between them can be seen in some phases as an indistinct wavy line, the primary intima being relatively thinner than in the pharynx. The intima in the region of the crop is also much more irregular in appearance than in the pharynx. The side toward the lumen of the intestine presents a rough uneven appearance and in some places bears spines which are often long and needle-like. These spines are longer and more numerous near the esophagial valve. They seem to be distributed irregularly. In the narrow anterior portion of the crop the intima is thrown into numerous folds which nearly fill the lumen of the intestine. Where the crop is distended there are only a few small folds distributed at intervals.

The epithelium of the fore-intestine is a thin layer composed of irregular shaped cells. It is thrown into folds following the folds of the intima. In stained sections a continuous purple line can be seen along the edge of the epithelium on the side next the intima. The nature of this dark band is uncertain The epithelial cells in most places are flattened and are much longer than thick, but in some places especially where the epithelium forms a fold they are cuboidal in shape.

In the crop the epithelium is even thinner than in the pharynx. In sections the epithelium appears in many places as a thin string with enlargements at intervals. One or more nuclei can be seen in most of these enlargements. The limits of the individual cells cannot usually be clearly distinguished except in the places where the cells are cuboidal in shape.

No basement membrane can be distinguished apart from the epithelial layer.

The logitudinal muscle layer of the fore-intestine is a continuous solid layer made up of a great number of bundles of muscle fibers. Nuclei are seen in many of the bundles, and are usually situated on the edges of the bundles as seen in cross-sections.

The circular muscle layer is a little thicker than the logitudinal layer. It is made up of rather thick muscle bands. Frequently there are three or four of these muscle bands running alongside each other. Numerous nuclei can be seen. They are often strung out in rows of four or five nuclei running lengthwise of the muscle. In longitudinal sections of specimens in which the crop is of nearly uniform diameter throughout its length the circular muscle layer becomes thicker as it nears the oesophageal valve. Where the crop is distended the muscle layers are much thinner than otherwise.

In longitudinal sections in which the crop is distended up to the point where it joins the pharynx, the pharynx appears to project slightly into the lumen of the crop.

No "peritoneal membrane" was observed.

Histological Structure of the Oesophageal Valve.

The oesophageal valve marks the point of junction of the fore- and mid-intestine. Just anterior to the stomach the walls of the fore-intestine become constricted. Then they project into the lumen of the stomach, turn back upon themselves, and unite with the walls of the stomach.

The intima as it enters the constricted portion of the valve becomes smooth and regular in appearance. It passes into the stomach, turns back around the projecting lobe of epithelium and disappears between the lobe of fore-intestinal epithelium and the first group of stomach cells.

As the fore-intestinal epithelium enters the constricted portion of the valve its cells become distinctly cuboidal in shape. As it enters the stomach and turns back upon itself the cells become columnar in shape. Just after it makes the turn the cells become extremely long and narrow and appear closely packed together. A cleft usually appears between the last of these epithelial cells and the first of the stomach cells.

Longitudinal muscles are not especially abundant in the region of the valve. In some longitudinal sections the ends of the large longitudinal muscles of the stomach can be seen extending into the constricted portion of the valve.

The circular muscle layer of the fore-intestine becomes thicker just anterior to the valve and passing into the constriction at the valve it nearly fills that constriction with large masses of circular muscle bundles which by their contraction serve to close the valve.

At the oesophageal valve the muscle layers reverse their positions in respect to each other. Anterior to the valve the circular muscles are outside the longitudinal muscles, posterior to the valve the reverse is true.

Histological Structure of the Mid-Intestine.

The mid-intestine extends from the oesophageal valve to the pyloric valve. A histological examination of the stomach wall gives the following sequence of tissues from within out; (1) an epithelium of endoderm cells, (2) circular muscles, (3) longitudinal muscles. A basement membrane can probably be seen in some places at the base of the epithelial cells. No "peritoneal membrane" has been observed. The structure of the stomach wall appears to be about the same throughout its length although the diameter of cross-sections taken from its various portions varies greatly.

The appearance of the epithelial layer varies with the different stages in the process of secretion. The cells are columnar shaped but are much longer at some times than at others. Sometimes the cells form a single layer but usually they are built up into papillæ. Sometimes these papillæ become very tall and nearly touch one another on their sides. This is especially noticeable in the narrow portion of the stomach. Nidi or "cell nests" appear at regular intervals and are conspicuous objects since they stain darkly. These are nests of embryonic tissue from which new cells arise. They lie below the rest of the epithelium and project in part through the muscle walls. Since there is usually a papilla standing up between each two nidi, each nidus appears to be situated at the bottom of a pit.

Both merocrine and holocrine types of secretion seem to be carried on. In some cross-sections the food material in the intestine is seen to be completely surrounded with a ring of little globules of digestive secretion. These globules can be seen issuing from the ends of the epithelial cells. Apparently the cells rupture at their ends and the fluid secretion contained in the extremity of each cell flows out forming a globule as it enters the lumen of the intestine. The cell wall at this emptied end then shrinks and becomes wrinkled and shrivelled in appearance. This gives the ends of the cells a striated appearance. At an apparently later stage the cells are seen to be tipped with filaments which are probably the frayed out walls of the cell ends which have just been described. Among the cells of this second stage can be seen some which show at their tips a convex surface within the filaments. This probably is the surface of new secretion which is welling up from the body of protoplasm below. This second secretion is thrown off much as in the first case. Apparently this process repeats itself as many as two or three times. In the first stage the cells formed a single layer. In the mean time they have been building up and forming papillæ. The nuclei gradually move out towards the tips of the cells and finally the entire mass of cells breaks down in the form of holocrine secretion. This latter process was plainly taking place in many of the sections which were examined. New cells then grow out from the nidi and replace the old ones.

The process which has just been described as the probable method of secretion in this insect was suggested to the author by Dr. C. H. Kennedy.

Just outside the epithelial layer are large circular muscle bundles. These bundles are more or less isolated and do not usually form a continuous layer. In some places, however, their ends overlap and they appear in cross-section as a nearly continuous ring around the epithelium.

Outside the circular muscles are the longitudinal muscles. These also occur as isolated bundles, thirty or forty or more of them being seen in a cross-section. Frequently several of these bundles are seen grouped together.

Between the epithelial layer and the circular muscles especially within folds of the epithelium, fine strands of tissue appear which are probably tracheoles. In such places there can be seen also apparently isolated nuclei. The nature of these is uncertain.

Histological Structure of the Hind-Intestine.

The malpighian tubules arise as outpocketings of the hind-intestine. In *Asaphes memnonius* they join the digestive tract just at the point of junction of the mid- and hind-intestine. The epithelium just anterior to the insertion of these tubules is composed of typical stomach cells while the epithelium immediately posterior to their insertion is covered with a thin layer of chitin which shows that it belongs to the hind-intestine.

The epithelial cells of the tubules are very irregular both in shape and size. Their irregular shape gives the lumen of the tube a very irregular outline. Frequently two large cells will have very small cells inserted between them. The nuclei are large and usually ovate in shape. The tubules are lined with a striated border. This border looks as if it were made up of a dense lining of fine filaments extending out from the epithelial cells and with a comparatively few longer filaments extending out beyond the tips of the others

At the origin of the tubules the epithelial cells appear crowded together and columnar in shape. Progressing distally from the basal end of the tubule the cells gradually assume their more characteristic appearance.

On the outside the Malpighian tubules are bounded by a narrow layer of connective tissue containing many nuclei.

The pyloric valve is situated just posterior to the point of insertion of the malpighian tubules. In *Asaphes memnonius* this valve is an unusually long structure occupying the entire length of the first bend in the hind-intestine

Immediately posterior to the insertion of the malpighian tubules the epithelial layer is thrown into a number of folds surrounding the lumen of the valve. The cells making up these folds are long and columnar shaped. As the epithelial layer passes from this point into the constricted portion of the valve the cells become cuboidal and finally small and irregular in shape, giving the epithelial layer somewhat the same appearance as the fore-intestinal epithelium. Throughout the constricted portion of the valve the epithelium is thrown into long folds running lengthwise of the valve. Near the posterior end of the valve where it is usually tightly constricted these folds practically obliterate the lumen of the valve. The epithelial layer is covered with an intima of chitin. The intima is very thin at the anterior end of the valve but becomes thicker toward the posterior end. At the point where the pyloric valve ends and is followed by a wider portion of the intestine the cells of the epithelium become much larger and assume rather suddenly the characteristic cuboidal shape of the cells of the hind-intestine. The end of the valve frequently projects slightly into the lumen of this portion of the intestine.

The pyloric valve is surrounded for its entire length by a conspicuous layer of circular muscles, and there is an especially dense mass of these muscles at the point where the valve makes a bend. Evidently the muscles serve to close the valve at this point.

Longitudinal muscles are found both outside and inside the circular muscle layer.

The hind-intestine proper begins at the end of the pyloric valve and extends to the anus The intestinal walls throughout this region show a close similarity of structure. The tissues are arranged in the following manner: (1) an inner intima of chitin, (2) an epithelial layer, (3) circular muscles, and (4) longitudinal muscles. In a few longitudinal sections taken from the anterior part of the hind-intestine there appeared to be some circular muscle bundles outside the longitudinal muscles

As was mentioned in the description of the gross structure, the hind-intestine proper appears externally to be divided into three regions, a narrow convoluted anterior portion, an enlarged median portion, and a narrow posterior portion. Although differing in diameter these regions do not appear to be greatly different in morphological structure. The walls of the anterior portion appear to be constricted. The epithelium is thrown up into folds as seen in both longitudinal and cross-sections. The epithelium of the narrow posterior portion is convoluted also. In the enlarged median portion the walls appear to be stretched and no convolutions appear. In some specimens in which the digestive tract was empty the hind-intestine appeared as a tube of nearly uniform diameter throughout its length. However, it appears that the median portion is the largest portion aside from the fact that its walls are usually distended.

The intima of the hind intestine is a thin layer of chitin adhering closely to the epithelial layer.

The epithelial layer is composed of cells which are usually columnar shaped although they are comparatively short and thick and many of them would be described as cuboidal. The nuclei are comparatively large ovate structures situated usually nearer the basal portion of the cells. When stained with eosin the outer ends of the cells stain darker than their basal portions. This gives the appearance of a dark band along the side of the epithelium next the lumen of the intestine. In places this band appears somewhat striated.

The circular muscles are found immediately surrounding the epithelium. They are numerous but do not usually form a solid layer. In places where the intestine is constricted there will be frequently two or three of these muscle bands running alongside each other.

The longitudinal muscles are outside the circular muscles They are larger than the circular muscles but not so numerous. In cross-sections they appear in groups scattered around the circumference of the section.

Where the epithelium is convoluted, both longitudinal and circular muscles are found running up into the folds in some places.

The muscles are striated as are all insect muscles. When they are contracted their edges have a beaded appearance.

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Alimentary Canal of Asaphes
John T. Bigham

PLATE I.

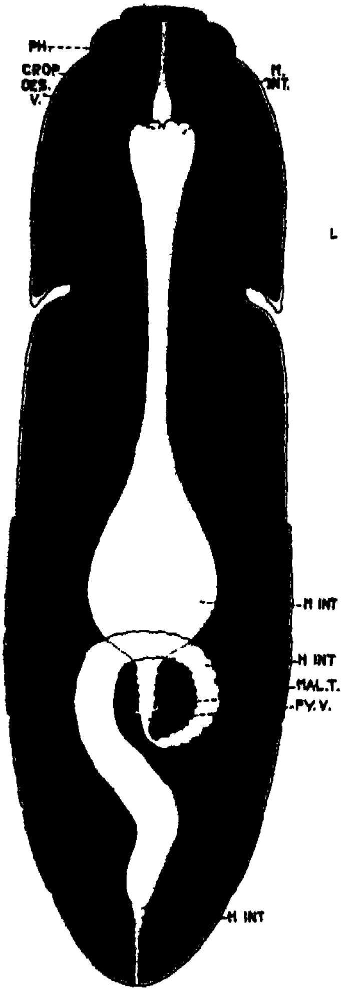

FIG. 1

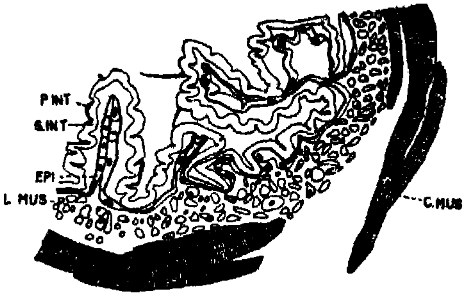

FIG. 2

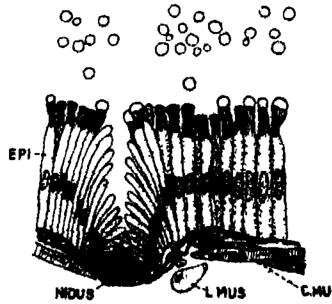

FIG 3.

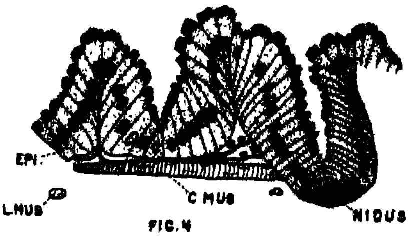

FIG. 4

Fig. 1. A dorsal view of the alimentary canal of *Asaphes memnonius*.
Fig. 2. Cross-section through constricted anterior portion of crop.
Fig. 3. Cross-section through mid-intestine showing "first stage" in the process of secretion.
Fig. 4. Cross-section through mid-intestine showing a later stage in the process of secretion.

KEY TO ABBREVIATIONS.

C. Mus.—Circular muscles.
Epi.—Epithelium.
H. Int.—Hind-intestine.
Int.—Intima.
L. Mus.—Longitudinal muscles.
Mal. T.—Malpighian tubule.
M. Int.—Mid-intestine.
Oes.—Oesophagus.
Oes. V.—Oesophageal valve.
Peri. mem.—Peritoneal membrane.
P. Mem.—Peritoneal membrane.
Ph.—Pharynx.
P. Int.—Primary intima.
Py. V.—Pyloric valve.
S. Int.—Secondary intima.

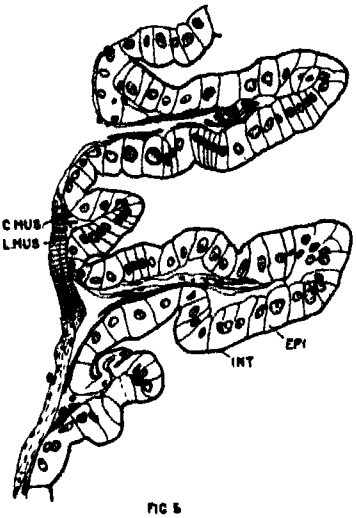

FIG 5

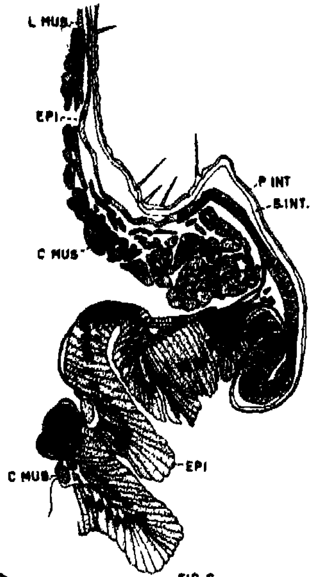

FIG 6

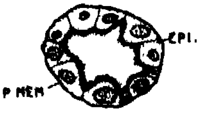

FIG 8

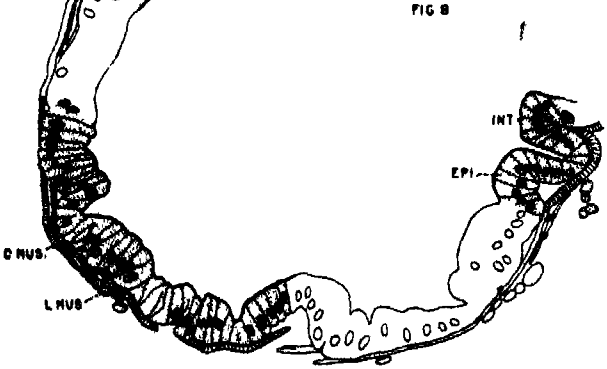

FIG 7

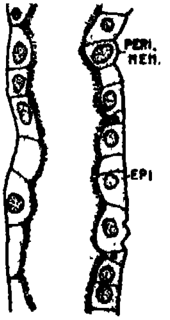

FIG. 9

Fig. 5. Longitudinal section through anterior convoluted portion of hind-intestine.
Fig. 6. Longitudinal section through oesophageal valve.
Fig. 7. Cross-section through posterior portion of hind-intestine.
Fig. 8. Cross-section of Malpighian tubule.
Fig. 9. Longitudinal section through Malpighian tubule.

NOTE: Figures 5, 6 and 7 are magnified approximately five-eighths as much as the other histological figures.

THE ALIMENTARY CANAL OF CRIOCERUS ASPARAGI LINN.

RALPH HOWARD DAVIDSON.

INTRODUCTION.

The common asparagus beetle (*Criocerus asparagi* L.) is a phytophagus insect pest of asparagus. It is widely distributed throughout the truck-growing areas of the United States.

The study that follows was made upon the suggestion of Dr. Rodney Cecil of the U. S. Bureau of Entomology, and was begun in a course in entomology at the Ohio State University, given by Dr. C. H. Kennedy on "The Morphology and Development of Insects."

The material used was collected at Geneva, New York. The beetles were opened and fixed in Kahle's solution for 24 hours, and preserved in 70% alcohol.

The author wishes to express his appreciation for the helpful suggestions and criticisms of Dr. C. H. Kennedy, under whose direction this study was made.

GROSS ANATOMY OF THE DIGESTIVE TRACT.

General Anatomy.

The alimentary canal consists of a simple tube with but few convolutions, which is characteristic of phytophagus insects. The canal is approximately one and one-fourth times the length of the insect's body Morphologically the canal is divisible into three primary regions according to their embryonic origin. The fore-intestine (Stomodaeum) arises as an anterior ectodermal invagination; the hind-intestine (Proctodaeum) arises as a similar posterior invagination; the mid-intestine (Mesenteron or Ventriculus) which connects the two, develops as an endodermal sac from a proliferation of rings of endodermal cells, one around the posterior end of the fore-intestine and the other around the anterior end of the hind-intestine. The relation of these parts to each other is shown in Fig. 6, Plate I.

Fore-Intestine.

The fore-intestine is a short slender tube which consists of the following regions: pharynx, oesophagus, crop, and oesophageal valve.

The pharynx is the slight enlargement of the fore-intestine just posterior to the mouth which connects the mouth with the oesophagus.

The oesophagus is a very short narrow tube connecting the pharynx with the crop. It is located in the anterior part of the prothorax, and increases slightly in size in the posterior part of the prothorax. This enlargement is the only indication of a crop being present.

The crop, as just stated, is represented by a slight enlargment of the posterior part of the oesophagus The variation in the size of this structure is probably due to the amount of food material it contained at the time the insect was killed. This portion of the canal lies in the prothoracic segment.

The oesophageal valve is well developed and marks the division between the fore-intestine and mid-intestine by a slight constriction. This constriction is found near the junction of the prothoracic and mesothoracic segments.

No salivary glands were found

Mid-Intestine

The mid-intestine forms the largest part of the alimentary tract. It is marked at its anterior end by the oesophageal valve, located near the anterior part of the mesothoracic segment, and at the posterior end by the pyloric valve and Malpighian tubules located in the seventh abdominal segment. The size of the mid-intestine or stomach varies with the different specimens dissected. This is apparently due to the different amounts of food material each stomach contained. The anterior part of the mid-intestine is usually small, and the mid- and posterior parts are large in size (Fig. 6, Plate I). Correlated with these two regions of the stomach is a slight differentiation of the epithelial lining.

Hind-Intestine.

The hind-intestine is made up of the following regions, pyloric valve, Malpighian tubules, ileum, colon, and rectum.

The pyloric valve is recognized by the constriction at the posterior end of the mid-intestine. It is located just anterior to the attachment of the Malpighian tubules to the ileum.

The Malpighian tubules are six in number and are divisible into two groups; the first group consisting of four tubules and the second of two tubules. The first group arises from a knob-like projection of the ileum just posterior to the pyloric valve, while the second arises as an evagination slightly anterior to the first group, in the region of the epithelium of the pyloric valve.

In the gross dissection the tubules are found to be entirely distinct from the walls of the canal, except near their distal ends where they penetrate the peritoneal layer of the colon. The approximate course of the tubules to the point where they enter the peritoneal layer, is shown very diagrammatically in Fig. 6, Plate I.

The vessels of the first group run cephalad, two on the dorsal side and two on the ventral side of the alimentary canal. They are embedded in the adipose tissue and follow the digestive tract in a more or less irregular or wavy path throughout most of its length. They extend forward as far as the crop and here turn caudad and follow the mid-intestine rather closely to its posterior end. At this point they leave the mid-intestine and follow an irregular course through the fatty tissue and the body cavity in the region of the pyloric valve. Finally two tubules from the first group unite at their distal ends, forming a common stem on the dorsal side near the anterior part of the colon. Immediately posterior to the union of these two tubules one of the tubules of the second group joins this same stem, forming a common duct This formation of a common duct is quite similar to that described for Halitica bimarginata Say (Woods, 1916). The three remaining tubules form a similar grouping on the ventral side of the colon.

The two tubules which make up the second group are smaller in size and shorter in length than those of the first. They follow an irregular course in the body cavity, being closely associated with the ileum and colon, finally each uniting with one of the common stems as described in the preceding paragraph

These two common stems, one dorsal and the other ventral, enter the peritoneal membrane of the colon and immediately separate into the six original Malpighian tubules. They follow a straight path a short distance and gradually increase in size, becoming flattened and convoluted in shape as they approach the posterior end of the colon. They do not branch but simply follow a very irregular course (Fig. 6, Plate I), bending and folding back on themselves until the posterior part of the colon is almost completely covered with a mass of convoluted Malpighian tubules. The tubules terminate blindly at the junction of the colon and rectum.

The ileum, frequently called the small intestine, is a small tube which connects the stomach with the colon. It extends posteriorly to about the ninth abdominal segment, and then turns sharply cephalad joining the colon in the seventh abdominal segment.

The colon connects the ileum with the rectum. At its anterior end it is almost the same size as the ileum but gradually increases in size posteriorly, reaching its maximum diameter just before the junction with the rectum.

The rectum is short and heavily muscled, and is of the same diameter as the oesophagus, as shown by sections of this area. It connects the colon with the anus.

HISTOLOGY OF THE ALIMENTARY CANAL.

Fore-Intestine.

The histological examination of the fore-intestine did not reveal any unusual structures. It is lined throughout with a rather heavy layer of chitin or intima. This layer is non-cellular and almost transparent, and is very difficult to stain. It projects into the lumen of the pharynx and oesophagus in irregular wave-like folds. As the oesophagus (Fig. 1, Plate I) gradually enlarges to form the crop (Fig. 2, Plate I), these folds become less pronounced.

The epithelium forms a single layer of rather flattened, irregular shaped cells with prominent nuclei. This layer of cells lies next to the intima and follows the wave-like folds throughout the fore-intestine. The cell walls are not very distinct, but the basement membrane is quite evident.

Outside of the epithelial layer are found well developed bundles of longitudinal muscle fibers. These are quite evident in all the sections of the fore-intestine but they gradually become smaller in the region of the crop.

Surrounding the longitudinal muscles is a well developed layer of circular muscle. These muscles are numerous in the folds of the oesophageal valve.

The oesophageal valve, (Fig. 4, Plate I), marks the junction of the fore-intestine with the mid-intestine. It consists of six folds which project into the lumen of the stomach. These folds are formed by the projection of the fore-intestine into the mid-intestine, which then fold back upon themselves in an outward direction to the anterior edge of the mid-intestine. At this point the intima of the fore-intestine ends and the digestive epithelium of the stomach begins. The epithelium of the valve is continuous with that of the fore-intestine. Circular muscles are numerous in the folds of the valve and they apparently function in its closing. The circular and longitudinal muscles reverse their positions at the point where the intima ends and the digestive epithelium begins. Strands of peritoneal membrane are evident in sections from this region.

Mid-Intestine.

The mid-intestine or stomach is that part of the alimentary canal posterior to the oesophageal valve and anterior to the pyloric valve.

In this part of the digestive tract there is no cuticular covering of the epithelial cells, and the position of the circular and longitudinal muscle layers is reversed as compared with that in the fore-intestine.

The peritrophic membrane, which is a structureless membrane found in the mid-gut, encloses the food in the stomach thus protecting the delicate secreting cells from injury by sharp food particles. It is apparently secreted near the juncture of the fore-intestine and the mid-intestine, since the sections showing it were from the anterior part of the mid-gut (Fig. 11, Plate II).

The cells of the digestive epithelium vary in size and shape depending upon their physiological condition at the time the insect was killed. In the specimens dissected which had fed very recently or were feeding prior to the time of killing, the epithelial cells are of the columnar type, being long and narrow (Fig. 11, Plate II), and showing holocrine secretion; while the epithelial cells in the specimens which were killed a few hours after feeding are much shorter, indicating that the epithelium had recently secreted. In general the epithelial cells are shorter in the posterior part of the mid-gut, (Fig. 5, Plate I). The nuclei are large and oval in shape, staining deep blue with Delafield's Haemotoxylin.

The secretion of the epithelial cells is holocrine, the entire contents of the cell bursting out into the lumen of the gut, after which the cell is replaced by new cells developed from nidi (nests of embryonic tissue scattered in the base of the epithelium). The nidi (Fig. 11, Plate II) are numerous and lie in the base of the epithelium along the basement membrane. The columnar cells burst as the digestive fluids are needed, and they are replaced by new cells splitting off on the sides of the nidi, which lengthen and fill with digestive fluid.

The circular muscles of the stomach consist of two narrow layers which are fairly well developed and are present throughout the length of the mid-gut.

The outer layer of the stomach consists of small strands of longitudinal muscle.

The thin delicate peritoneal membrane is also present.

Hind-Intestine.

The hind-intestine is marked anteriorly by the pyloric valve and posteriorly by the anus.

The pyloric valve (Fig. 5, Plate I) consists of very narrow columnar cells which are arranged in irregular fan-shaped groups. The intima which lines the valve and continues throughout the hind-intestine originates at the junction of the mid- and hind-intestine. These fan-shaped groups of cells probably function as a valve, since this region is surrounded by a heavy layer of circular muscle which upon contraction apparently could close the valve.

The Malpighian tubule attachments have been described under gross anatomy of the alimentary canal. Histological examination of the tubules at their respective points of origin shows that the epithelial cells are very similar to those cells making up the pyloric valve, being narrow and elongate and having conspicuous nuclei. Later they assume the characteristic cuboidal shape a short distance from the point of attachment. Intima is present in the tubules but is difficult to detect a short distance from the point where they join the ileum. In a typical cross-section they are made up of from four to six cuboidal cells with large conspicuous nuclei, and are surrounded by a very thin peritoneal membrane (Fig. 3, Plate I). A cross section from A to B in Fig. 5, Plate I, is shown in Fig. 7, Plate II. This shows the opening through which the excretions from the Malpighian tubules of the first group must pass in entering the ileum.

There is a gradual change from the region of the valve to that of the ileum, the intima becoming more wavy in outline, the epithelial cells and their nuclei becoming larger in size, and the circular muscles decreasing slightly in size. The longitudinal muscles consist of a few isolated strands.

The ileum (Fig. 8, Plate II) forms the connecting link between the pyloric valve and the colon. The layers of intima, epithelium, basement membrane, and circular and longitudinal muscle of the ileum are continuous with those of the colon. In the colon the folds of the intima are less pronounced, and the epithelial cells are slightly larger.

The circular muscles consist of a single layer which is prominent at the anterior part of the colon but gradually decreases in size towards the posterior end.

The longitudinal muscles are fairly well developed at the anterior end and gradually increase in size posteriorly.

The distal ends of the Malpighian tubules also form a layer around the colon. The entrance of the tubules into the delicate nucleated layer of peritoneal membrane was described under gross anatomy. A cross section of the anterior part of the colon shows the six Malpighian tubules (Fig. 9, Plate II) in the peritoneal membrane.

Proceeding caudad serial sections of the colon show an increasing number of sections of Malpighian tubules. This is due to the convoluted shape of the tubules and the winding course followed by them in the posterior part of the colon. A cross section of the extreme posterior part (Fig. 10, Plate II) shows almost a continuous layer of Malpighian tubules around the colon, which would seem to indicate that the tubules branch.

Woods (1916) states that the Malpighian vessels of *Haltica bimarginata* Say seem to branch irregularly. It was found that they do not branch but follow a very irregular course (Fig. 6, Plate I) in the peritoneal layer. The colon is almost completely covered with tubules near the posterior end, so that in a cross section of this region a number of sections of the same tubule are made, thus forming a continuous layer. The tubules end blindly in the peritoneum at the junction of the colon and rectum.

The rectum connects the colon with the anus. The colon ends rather abruptly and the heavy circular muscle layers mark the beginning of the rectum. The intima and epithelium project into the lumen of the rectum in from five to eight wavy folds, (Fig. 12, Plate II), these becoming more pronounced posteriorly. The nuclei of the epithelial cells are large, the cell walls being indistinct and the cells being somewhat smaller than those of the colon Outside of the epithelial cells is the basement membrane, which is fairly distinct The circular muscles are well developed and are composed of three or four layers. Longitudinal muscle is present in a few isolated strands.

SUMMARY.

Morphologically the canal is divided into three primary regions, namely, fore-intestine, mid-intestine, and hind-intestine.

The fore-intestine is represented by the following parts; pharynx, oesophagus, crop, and oesophageal valve.

The mid-intestine is represented by the stomach.

The hind-intestine consists of the following regions; pyloric valve, Malpighian tubules, ileum, colon, and rectum.

Histological examination of the fore-intestine reveals a similarity in structure of the various parts. The layers represented from within out are: intima, epithelium, basement membrane, longitudinal muscle, circular muscle, and peritoneal membrane.

In the mid-intestine the layers from within out are: peritrophic membrane, epithelium, basement membrane, circular muscle, longitudinal muscle, and peritoneal membrane.

The layers in the hind-intestine from within out are: intima, epithelium, basement membrane, circular muscle, longitudinal muscle, and peritoneal membrane.

There are six Malpighian tubules present in *Criocerus asparagi* Linn. The distribution of these tubules is as follows, beginning at their distal ends. From their point of attachment at the distal end of the colon, the tubules follow a convoluted course running cephalad in the peritoneal membrane. They unite at the anterior end of this region to form two common trunks. These two trunks upon leaving the wall of the colon, each split into a single tube and a common stem representing a pair of tubes. The single tubes follow an irregular course in the region of the ileum and finally become attached to an evagination of the epithelium of the pyloric valve. Each common stem soon separates into two tubules which have a long course in the body cavity, running cephalad to the crop. Here they turn caudad following the mid-gut to its posterior end, where the four vessels unite to form a knob-like structure or urinary bladder, which empties into the hind-intestine just posterior to the pyloric valve.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Cross-section of oesophagus.
Fig. 2. Cross-section of crop.
Fig. 3. Cross-section of Malpighian tubule.
Fig. 4. Longitudinal section of oesophageal valve.
Fig. 5. Longitudinal section of pyloric valve. This section also shows the posterior part of the stomach, the anterior part of the ileum, and the duct formed by the attachment of the group of four Malpighian tubules.
Fig. 6. Diagrammatic dorsal view showing alimentary canal and Malpighian tubules. The Malpighian tubules on the colon are in the peritoneal membrane.

PLATE II.

Fig. 7. Cross-section from A to B in Fig. 5, Plate I, showing the duct of the group of four Malpighian tubules.
Fig. 8. Cross-section of ileum.
Fig. 9. Cross-section of anterior part of colon, showing the six Malpighian tubules in the peritoneal membrane.
Fig. 10. Cross-section of the posterior part of the colon showing a continuous layer of tubules in the peritoneal membrane
Fig. 11. Cross-section of stomach showing the peritrophic membrane and holocrine secretion.
Fig. 12. Cross-section of rectum.

KEY TO ABBREVIATIONS.

B. M.—Basement membrane.
C. D.—Common duct.
C. M.—Circular muscle.
CR.—Crop.
CO.—Colon.
DU.—Duct.
EPI.—Epithelium.
IL.—Ileum.
INT.—Intima.
L. M.—Longitudinal muscle.
M. I.—Mid-intestine.
M. T.—Malpighian tubule.
M. T. A.—Malpighian tubule attachment.
NI.—Nidus.
OES.—Oesophagus.
OES. V.—Oesophageal valve.
PH.—Pharynx.
PER. M.—Peritrophic membrane.
P. M.—Peritoneal membrane.
P. V.—Pyloric valve.
REC.—Rectum.

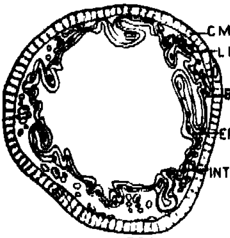


FIG. I

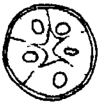


FIG. 3

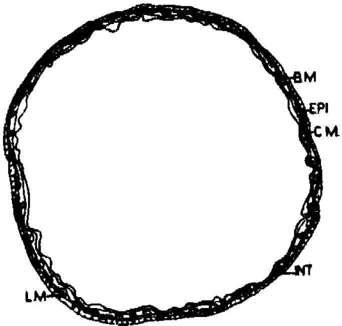
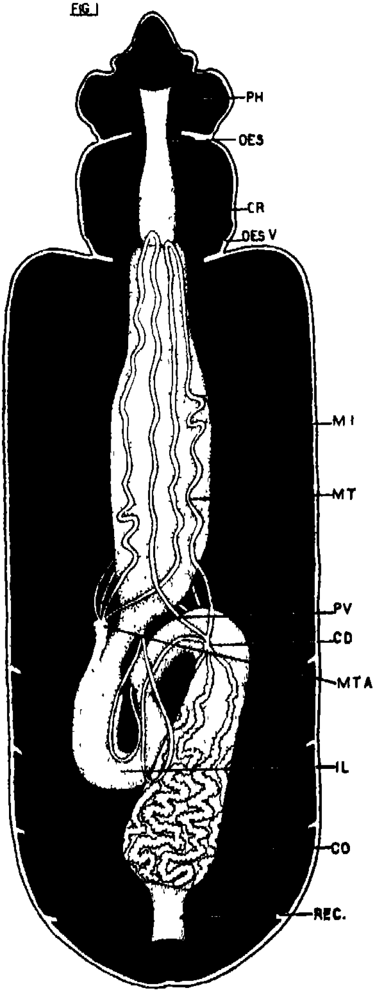


FIG. 2



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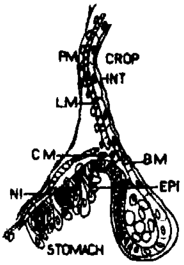

FIG. 4

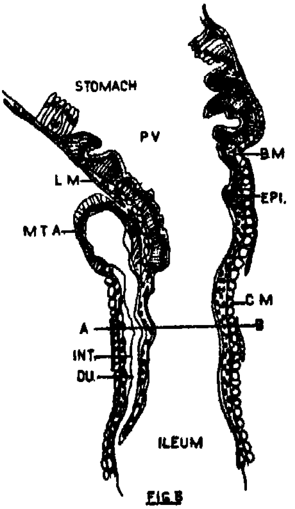

FIG. 5

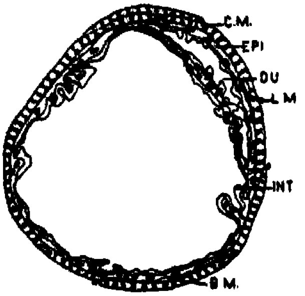

FIG. 7

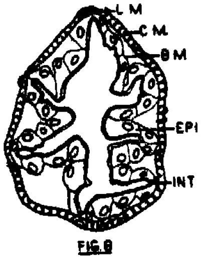

FIG. 8

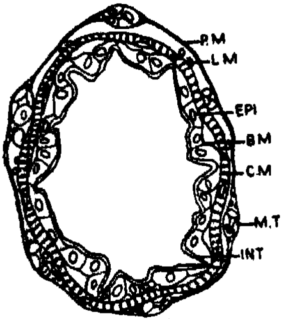

FIG. 9

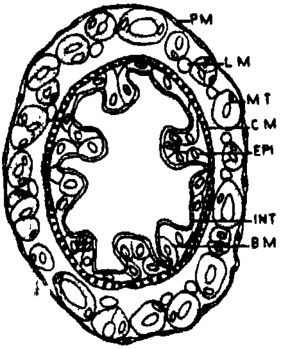

FIG. 10

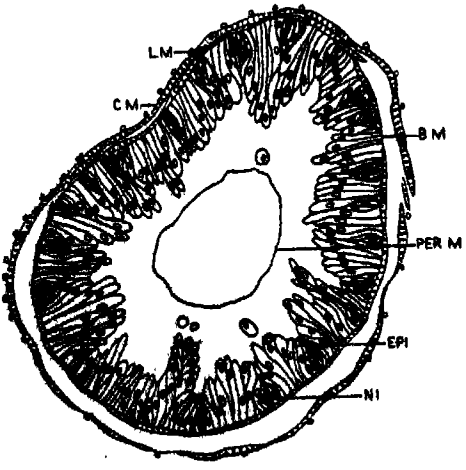

FIG. 11

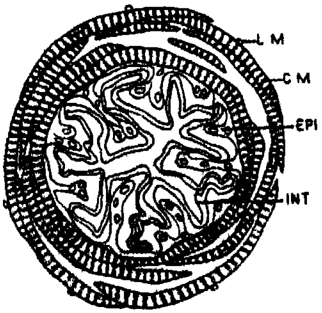

FIG. 12

THE ALIMENTARY CANAL OF SPHAERODERUS NITIDICOLLIS CHEV. VAR. SCHAUMI CHD. (COLEOPTERA)*

PAUL EVERETT SCHAEFER.

During the summer of 1930, while collecting insects at the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio, one of the carabidæ was found feeding on snails. The species was identified by Mr. L. L. Buchanan of the U. S. National Museum as *Sphaeroderus nitidicollis Chevrolat variety schaumi Chaudoir.* The species was found in a restricted locality on but one of the islands in that vicinity. The beetle is about two centimeters long, has a narrow head and prothorax, large mandibles and is of a violaceous color. Since the writer is very much interested in Carabidæ in general, at the advice and direction of Dr. C. H. Kennedy a study of the internal morphology of this species was undertaken.

The species ranges from Hudson Bay to northern Virginia but is rarely taken. Comparatively few specimens were found even after intensive search. These were fixed in Kahle's fluid and preserved in seventy per cent alcohol. The study was carried on through the fall and winter, but the scarcity of material made it somewhat restricted. It is hoped that more material may be obtained in order to complete a more intensive study of the morphology and physiology.

The author wishes to express deep appreciation for the suggestions, criticisms and assistance so freely given by Dr. Kennedy and for the helpful comments of many of his fellow-students.

GROSS ANATOMY OF THE DIGESTIVE TRACT.

There are three main divisions of the alimentary canal determined by the embryonic origin. The anterior portion (stomodaeum or fore-gut) arises as an invagination at the cephalic end of the embryo. The posterior portion appears similarly at the caudal end. These two parts, therefore, are ectodermal in origin. The mesenteron or mid-gut is formed by the proliferation of cells in the endodermal tissue and eventually connects the fore-gut to the hind-gut forming a continuous tube.

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*Presented in partial fulfillment of the requirements for the degree of Master of Science at Ohio State University.

The three regions are further differentiated to forms:

1. Fore-gut.
    - a. Mouth or buccal cavity.
    - b. Pharynx.
    - c. Oesophagus.
    - d. Gizzard (proventiculus).
    - e. Oesophageal valve.
2. Mid-gut (venticulus).
    - a. Anterior mid-gut.
    - b. Posterior mid-gut
3. Hind-gut
    - a. Pyloric valve.
    - b. Malpighian tubules.
    - c. Ileum.
    - d. Rectum.
    - e. Anal opening.

Though some variation occurs the different parts will usually be found to lie as follows: The fore-gut passes caudad along the median axis to the first abdominal segment where it joins the mid-intestine. The mid-intestine continues caudad for about a quarter of its length bending to the right in the second abdominal segment then sharply to the left. The posterior quarter of the mid-gut curves dorsad, at right angles to the antero-posterior axis, and joins the ileum at about the fourth abdominal segment The ileum curves left and ventrad sometimes forming a sharp half loop, to the sixth abdominal segment joining the rectum, which is more or less covered by the chitinous sheath surrounding the genitalia. The rectum is bellows-like and capable of considerable elongation.

The Fore-Intestine

The alimentary tract of the adult is about three cm. long, approximately one and a half times the length of the body, of this, the fore-gut comprises a little more than one fourth. The ***pharynx*** appears as a short dilated portion just posterior to the mouth. The ***oesophagus*** normally is smaller than the pharynx but is capable of some dilation. The ***gizzard*** or proventriculus may be distinguished as an enlarged rounded portion just anterior to the junction of the fore-gut and the mid-gut. The ***oesophageal valve*** is not apparent externally.

The Mid-Intestine.

The mid-intestine forms somewhat more than a third of the entire tract and is divided into two distinct portions approximately equal in length. The anterior portion is about twice the diameter of the posterior part but both are densely covered with papillæ those on the posterior portion being smaller, gradually diminishing in size towards the distal end.

The Hind-Intestine.

The beginning of the hind-gut is marked by the ***malpighian tubules*** of which there are four each having a separate entry, though the two dorsal tubes are somewhat nearer each other than the dorso-ventral tubes on either side. (See Fig. 12, Plate III). The tubes are long and greatly coiled, so much so that they could not be measured in the preserved material, no fresh material being available. The *pyloric valve* is immediately anterior to the tubules but is not distinguishable externally. The hind-gut makes up approximately one-third of the digestive tract. The *ileum* is but little more than half the diameter of the posterior mid-gut though it comprises a little less than two-thirds of the hind-intestine. There appears to be a constriction at the junction of the ileum and rectum but no valve was demonstrated. The *rectum* is somewhat cone-shaped the anterior portion being the larger, in this region the ovoid rectal pads, six in number, show plainly through the transparent wall. Due to the bellows-like form of the rectum it may be elongated considerably.

On either side of the rectum appears a comparatively large ovoid sac the ducts of which open one on either side of the anus. These are probably the anal glands from which a rather acrid fluid is emitted if the insect is disturbed.

HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL.

Histological Structure of the Fore-Intestine.

The fore-intestine being formed by the invagination of the body wall has approximately the same structure. Microscopical study of cross-sections from this region demonstrates the following differentiated areas: (1) a chitinous inner lining, intima, (2) an epithelium of hypodermal cells, (3) longitudinal muscles, (4) circular muscles, (5) and an enveloping membrane of connective tissue, "Peritoneum." (This term is improperly applied to insect tissue.)

The general structure of the fore-gut is the same throughout though some differences in detail may be noted.

The chitinous intima is plainly visible from the mouth to the junction of the fore-intestine and the ventriculus. In the anterior portion of the tube it is smooth and comparatively thin, but posteriorly it becomes thickened and densely covered with cilia-like structures, within the gizzard chitinous pads are found between the teeth. (See Fig. 5, Plate II.)

The epithelial layer of hypodermal cells is not so apparent in the oesophagus, individual cells being somewhat flattened. In the gizzard, however, they are either cuboidal or columnar in form and may be readily distinguished. (See Fig. 5, Plate II).

The longitudinal muscles of this region are gathered into four groups which lies in folds of the epithelium. Cephalad these groups are small, becoming larger in the pro-ventriculus, (See Figs. 2 and 4, Plate I, Fig. 5, Plate II).

The circular muscles appear outside the longitudinal muscles in scattered strands near the head but increasing to several layers around the pro-ventriculus (gizzard). (See Figs. 2 and 4, Plate I, Fig. 5, Plate II).

Traces of a "peritoneal membrane" composed of connective tissue may be found here and there, though it is largely obscured by the fatty tissue surrounding the fore-gut.

The oesophageal valve is located at the junction of the fore- and mid-intestine. This consists of a fold of the fore-gut which extends but slightly into the lumen of the mid-gut At this point the numerous circular muscles largely fill the constriction between the gizzard and the ventriculus. In this region there is a complete reversal in the position of the muscles, the longitudinal muscles of the mid-gut lying outside the circular muscles. (See Fig. 3, Plate I).

Histological Structure of the Mid-Intestine.

The mid-intestine which is bounded anteriorly by the oesophageal valve, posteriorly by the pyloric valve, is divided into two distinct regions approximately equal in length, the anterior portion being nearly twice the diameter of the posterior part. This region is entirely covered by papillæ, those of the fore part being much larger than the ones on the hinder portion.

A histological study of the mid-gut shows the two parts to be much the same save for size. Four rather definite layers are distinguishable: (1) epithelium of endodermal tissue, (2) circular muscles, (3) longitudinal muscles and (4) connective tissue termed the "peritoneal membrane."

The epithelial layer may vary in form and appearance depending on whether it is in the resting phase or the secretory phase. Shortly after taking food the cells are distended some of them breaking off to supply digestive fluids (holocrine secretion). These cells burst and pass off, new cells being formed by certain regenerative tissues contained in the crypts. (See Fig. 8, Plate II). There is some evidence for a merocrine secretion as well, for large globules of liquid may be noted exuding from the crypts during certain phases of the digestive process. (See Fig. 8, Plate II).

The papillæ which cover the surface of the mid-intestine, commonly termed crypts, contain at the tip a mass of generative tissue called a nidus. These nidi probably form the secretory cells of the epithelial layer. The nidi have sunken into the wall of the ventriculus, eventually breaking through to form the crypts which appear on the outer surface of the mid-gut. These are not what are ordinarily termed gastric coecae.

Just outside the basement membrane the circular muscle may be seen; ordinarily two or three layers appear.

The longitudinal muscles (which are reversed in position relative to those of the fore- and hind-gut) appear only in scattered groups and are not numerous.

A very thin "peritoneum" surrounds the entire mid-intestine. (See Figs. 6 and 7, Plate II).

(Although a differentiation occurs in the two regions of the mid-gut no valve was found between them and no division in function is discernible unless the fore part which has the larger crypts is primarily digestive and the hinder portion absorptive. However, much the same type of epithelial cells appear in both regions. (See Figs. 6 and 7, Plate II).

Histological Structure of the Hind-Intestine.

Externally the division between the hind-intestine and the ventriculus is marked by the malpighian tubules. Those are made up of large irregular cells with rather large ovoid nuclei. (See Fig 21, Plate III). The cells may vary in number from five to twelve in cross section. The inner surface of the tubules appears to be striated, though this does not appear for a short space from the opening into the lumen of the gut. The outer surface is covered by a very thin membrane.

A histological examination of the hind-gut reveals, (1) an intima, (2) an epithelial layer of hypodermal cells, (3) a layer of circular muscle, (4) an outer layer of longitudinal muscle and (5) a "peritoneum" of connective tissue.

Internally the division between the ventriculus and the hind-intestine is marked by the pyloric valve. This consists of a definite fold in the epithelial layer of the ileum. (See Fig. 9, Plate III).

The intima in the region of the pyloric valve is so thin that it is not apparent though it may be plainly seen in the rectum.

The inner layer of longitudinal muscle which ordinarily should be found in the hind-gut does not appear.

The circular muscles which function in closing the valve are very numerous. (See Fig. 9, Plate III).

Just outside the layer of circular muscle may be found a few strands of outer longitudinal muscle. (See Fig. 9, Plate III).

A very thin "peritoneum" is found surrounding the pyloric region.

The intima of the ileum is so thin it appears merely as a line, but the epithelial layer is very thick. The epithelial cells in the ileum are columnar and form folds which almost completely fill the lumen of the tube. Two or three layers of circular muscles are visible but the longitudinal muscles are evident only as a few scattered groups.

The rectum is much greater in diameter than the ileum, though the walls are very thin, so thin that in the anterior portion the six large ovoid rectal pads lying on the inner surface may be plainly distinguished. The intima of the rectum is thicker than in any other part of the hind-gut.

The rectal pads are composed of large columnar cells which form pads between the intima and the basement membrane. (See Fig. 14, Plate III). Outside the pads the thin epithelial layer is visible.

The circular muscles are but scattered strands and the longitudinal muscles may be seen only in one or two isolated groups.

The connective tissue or "peritoneum" appears only here and there. (See Fig. 14, Plate III).

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Dorsal view showing gross dissection of the Alimentary Canal. OES.—oesophagus; GIZ.—gizzard (proventriculus); A.M-GUT—anterior mid-gut; P. M-GUT—posterior mid-gut; M. TUB.—malpighian tubule; IL.—ileum; REC. PAD—rectal pad; AN. GL.—anal gland.

Fig. 2. Cross-section through the Oesophagus. EPI.—hypodermal epithelium; LU.—lumen of fore-intestine; IN.—intima; C. MUS.—circular muscle; L.MUS.—longitudinal muscle; MUS.?—probably muscle. (This section is magnified approximately one and a half times more than the section of the oesophagus caudad to this in Fig. 4.)

Fig. 3. Longitudinal section showing the Oesophageal Valve. EPIT.—endodermal epithelium; OES. VL.—oesophageal valve; LU.—lumen of fore-intestine; EPI.—hypodermal epithelium; IN.—intima; OES.—oesophagus; CE.—crypt on mid-gut; C. MUS.—circular muscle; C. TIS.—connective tissue, "Peritoneum;" L. MUS.—longitudinal muscle.

Fig. 4. Cross-section through the Oesophagus posterior to Fig. 2. C. MUS.—circular muscle; C. TIS —connective tissue, "peritoneum;" L. MUS.—longitudinal muscle; LU.—lumen of fore-gut; IN.—intima; EPI.—hypodermal epithelium.

PLATE II.

Fig. 5. Cross-section through the Gizzard (proventriculus). C. TIS.—connective tissue, "peritoneum;" C. MUS.—circular muscle; L. MUS.—longitudinal muscle; EPI.—hypodermal epithelium; IN.—intima; LU.—lumen of fore-gut.

Fig. 6. Cross-section through the anterior Mid-Gut. LU.—lumen of mid-gut; EPIT.—endodermal epithelium; C. MUS.—circular muscle; L. MUS.—longitudinal muscle; CR.—crypt.

Fig. 7. Cross-section through the posterior Mid-Gut. LU.—lumen of mid-gut; EPIT.—endodermal epithelium; C. MUS.—circular muscle; L. MUS.—longitudinal muscle; CR.—crypt.

Fig. 8 Longitudinal section through a Crypt of the anterior mid-gut. HOL.—holocrine secretion; EPIT.—endodermal epithelium; C. MUS.—circular muscle; L. MUS.—longitudinal muscle; C. TIS.—connective tissue, "peritoneum;" SEC.—globule of secretion (merocrine).

PLATE III.

Fig. 9. Longitudinal-section through the Pyloric Valve. EPIT.—endodermal epithelium; C. MUS.—circular muscle; L. MUS.—longitudinal muscle; PY. VL.—pyloric valve; C. TIS.—connective tissue, "peritoneum;" LU.—lumen of hind-intestine.

Fig. 10. Detail drawing of Fig. 12. M. TUB.—malpighian tubule; C. TIS.—connective tissue, "peritoneum;" L. MUS.—longitudinal muscle; CR.—crypt; C. MUS.—circular muscle; EPI.—hypodermal epithelium (?); ?—probably epithelial tissue; LU.—lumen of hind-gut.

Fig. 11. Cross-section through a Malpighian Tubule. S. B.—striated border; LU.—lumen of tubule; C. TIS.—connective tissue, "peritoneum."

Fig. 12. Diagrammatic drawing made from series of sections to show entry of each of the four Malpighian Tubes.

Fig. 13. Cross-section through the Ileum. L. MUS.—longitudinal muscle; C. MUS.—circular muscle; LU.—lumen of hind-gut; EPI.—hypodermal epithelium; C. TIS.—connective tissue, "peritoneum."

Fig. 14. Cross-section through the Rectum showing the Rectal Pads. REC. PAD—rectal pad or gland; IN.—intima; EPI.—hypodermal epithelial tissue; L. MUS.—longitudinal muscle; C. MUS.—circular muscle; LU.—lumen of hind-gut.

Alimentary Canal of Sphaeroderus
Paul Everett Schaefer

PLATE I.

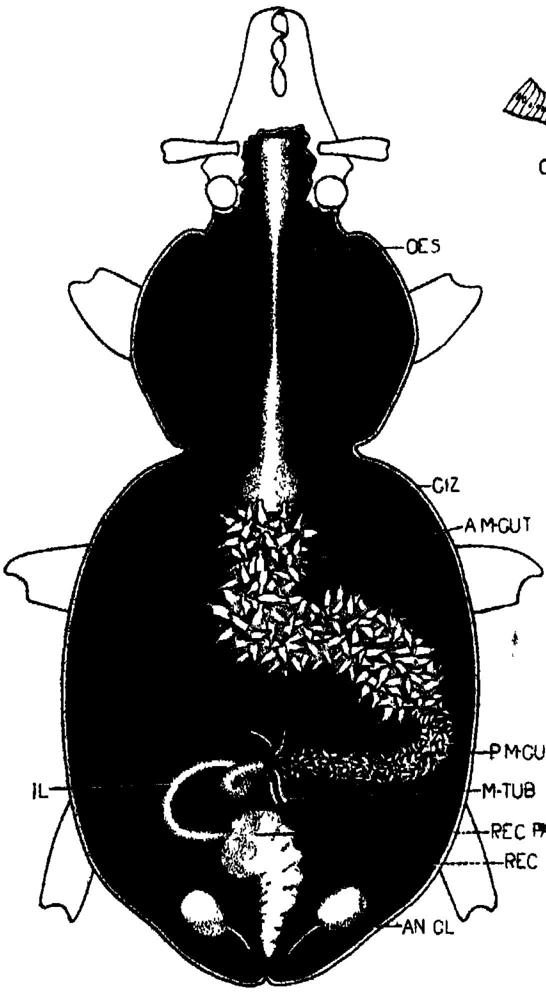

FIG 1

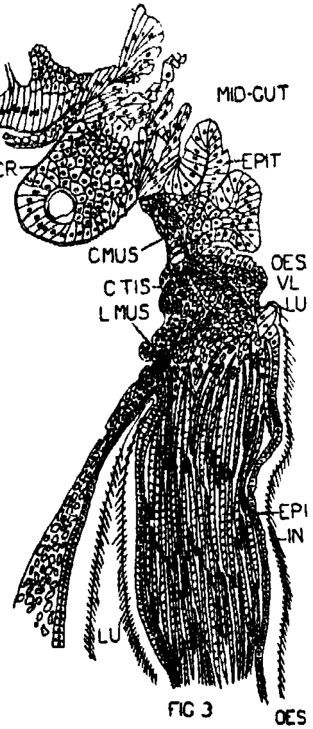

FIG 3

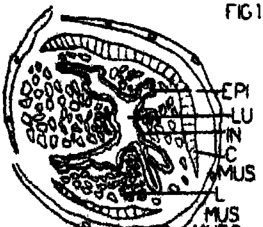

FIG 2

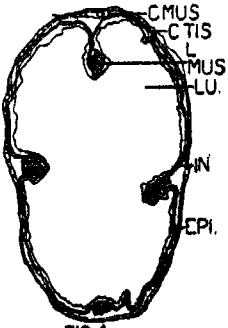

FIG 4

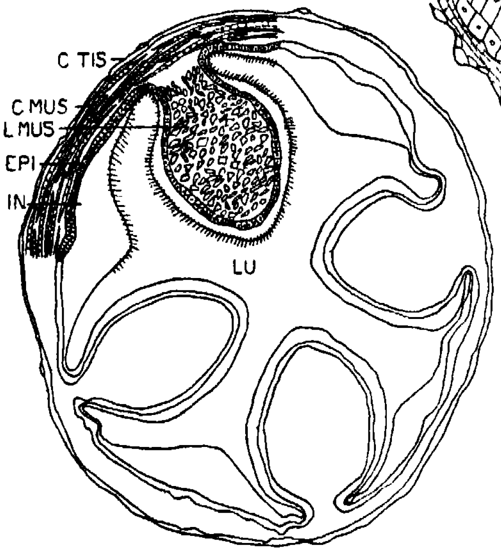

FIG 5

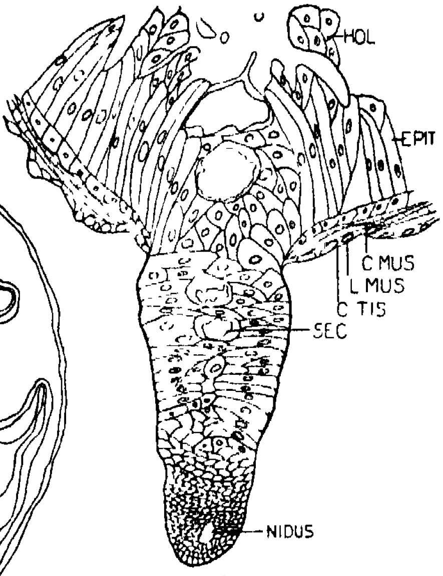

FIG 8

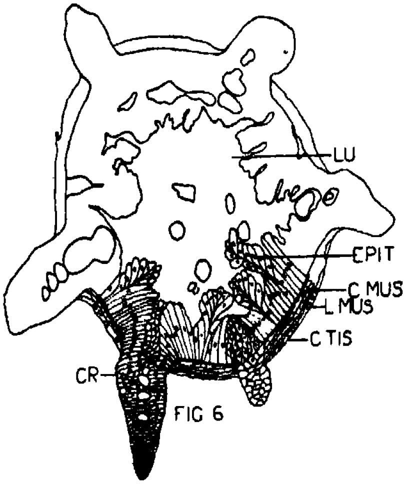

FIG 6

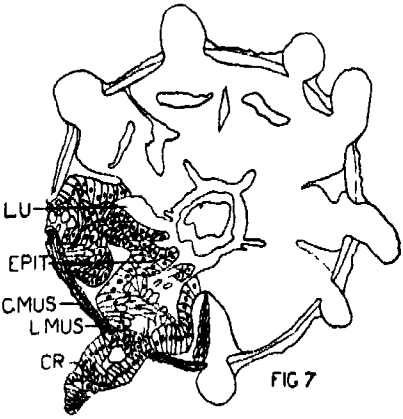

FIG 7

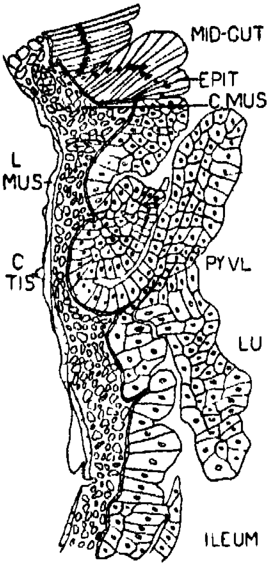

FIG 9

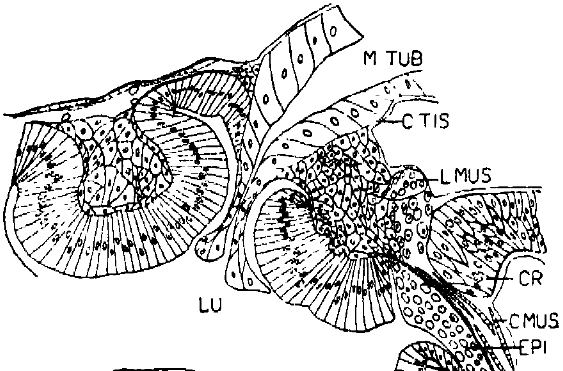

FIG 10

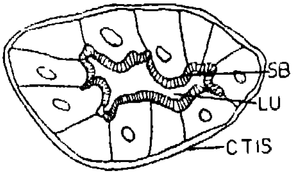

FIG 11

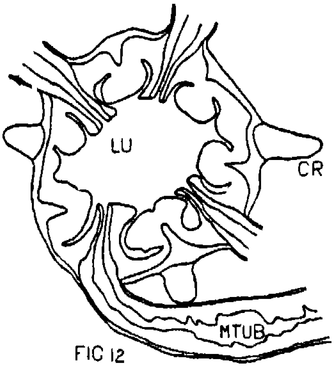

FIG 12

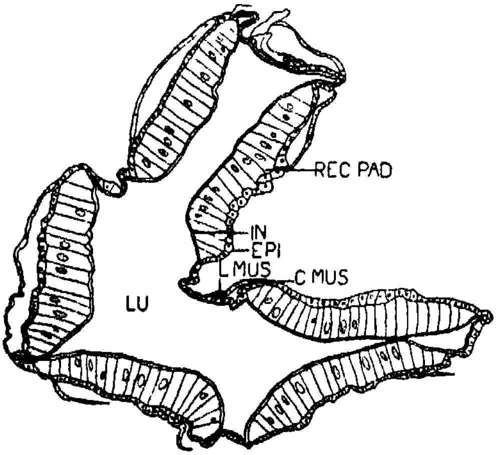

FIG 14

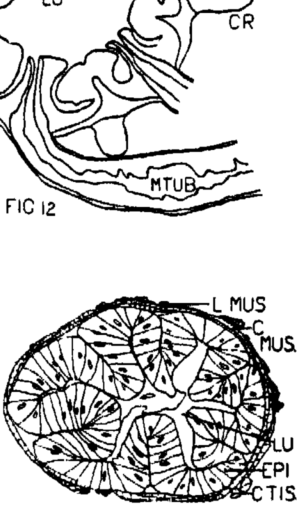

FIG 13

BISPORANGIATE INFLORESCENCES IN PSEUDOTSUGA.

E. W. LITTLEFIELD,
New York Conservation Department, Albany, N. Y.

In June, 1926, while examining some Douglas fir trees, (*Pseudotsuga taxifolia*, Britton) about fifteen years of age, on the grounds back of the State Capitol at Albany, N. Y., the writer noted, on one, some inflorescences which, although growing in normal position among other pistillate flowers, had an abnormal appearance. Specimens were accordingly collected and examined more closely with regard to the arrangement and structure of the various parts.

The strobili in question bore normal, ovulate scales, with bracts, on the upper portion, and staminate structures on the lower half of the axis. They were not so well developed as the normal pistillate flowers found on the same and neighboring trees, the largest measuring only 25 mm. in length, of which the lower 10 mm. were occupied by the stamens.

The sporophylls, both macro- and micro-, at the upper and lower extremities respectively, of the axis, appeared entirely normal in size and structure. Along the mid-section of the axis, however, sporophylls were found which apparently constituted transitional structures. In some cases there were normally shaped ovuliferous scales which, however, bore ovules that were distorted and apparently abortive; in others, the entire sporophyll was abnormal, with a scale-like structure at the base, surmounted by a poorly developed stamen, with an elongated spur.

During the past few years, as time permitted, the writer has examined the literature on this subject, without finding any previously recorded observation of this kind relative to *Pseudotsuga*. Similar occurrences in the case of a number of other conifers, however, have been reported. Dickson (1) described such inflorescences for *Picea Abies*. Bisporangiate cones on *Sequoia* were reported by Shaw (2). Fisher (3) observed abnormal cones on *Pinus laricio* which, though in the normal position of the staminate flower, had staminate structures only on the lower four-fifths of the axis, with pistillate on the remainder. Kirkwood's (4) description of bisporangiate flowers on *Larix occidentalis* is almost parallel to the condition described in this paper on *Pseudotsuga* except that in the former, the abnormal cones were as large as the normal ovuliferous ones. Dallimore and Jackson (5) mention the occurrence of bisexual cones in the case of *Pinus thunbergii*, though not giving a specific authority for the observation.

The writers cited above agree for the most part in their interpretation of the phenomenon of bisexuality in conifers, namely, as exemplifying the homology of the stamen with the bract of the carpellate cone. Kirkwood cites Coulter and Chamberlain's well-known work on "The Morphology of Gymnosperms" in this regard. Fisher (loc. cit.) goes further and takes up the discussion relative to the homology of the ovuliferous scale. In this he favors the theory that the scale is a secondary structure developed as a ligulate or chalazal outgrowth of the carpellate bract, citing a previous paper by Bessey in support of this attitude.

More recently, Schaffner (6) has discussed in considerable detail the matter of sexual reversal in monoecious inflorescences. Although this writer does not touch directly upon conifers, the paper cited has some bearing on the principles involved in the occasional development of bisexual cones in the Coniferæ and is of still further interest by reason of a description which is given of a bisexual catkin of *Salix amygdaloides*. Although this was considered as being essentially a staminate catkin, the arrangement of the organs was the same as found in similar inflorescences among the conifers, the pistillate appearing on the upper and the staminate on the lower part of the axis with various transitional structures between. A more complete description of the finding of this and other sexual phenomena in *Salix* is given by the same author in a previous paper (7).

(1) Trans. Edin. Bot. Soc. 6: 418–422, 1860.
(2) Bot. Gaz. 21: 332–339, 1896.
(3) Ohio Nat. 6: 396–397, 1905.
(4) Bot. Gaz. 61: 256–257, 1916.
(5) Handbook of Coniferæ: 466, London, 1923.
(6) Ohio Jour. Sci. 21: 185–200, 1921.
(7) Ohio Jour. Sci. 19: 409–416, 1919.

ABSTRACTS.*

PSYCHOLOGY SECTION.

Suggestibility as Influenced by the Form of the Question.—By **Harold E. Burtt**, Ohio State University.

Moving picture news reels were presented and subjects questioned immediately. Six forms of question were used over 5000 times each as follows:

(a) Did you see a . .. ; (b) Did you see the ; (c) Didn't you see a ; (d) Didn't you see the ; (w) Was there a ; (x) Wasn't there a .

The erroneous admission of the presence of an object was construed to reflect suggestibility in the form of the question. Three aspects were analyzed, the nature of the article, the negative vs. positive form, and the subjective vs. objective form. Results regarding the first of these were equivocal. There is a somewhat statistically significant trend for the negative to carry greater suggestion than the positive form although there seems one clear exception to this trend. With regard to the subjective and objective forms the latter shows clearly a higher degree of suggestibility.

An Experiment on the Relative Effectiveness of the Lecture-quiz and the Recitation Methods of Class Instruction in Elmentary Psychology.—By **H. H. Remmers**, Purdue University.

The object of this experiment was to determine the relative achievement of students under two different methods of instruction in Elementary Psychology: the lecture-quiz method and the recitation method. The lecture-quiz group containing approximately 150 students met twice a week for lecture and once a week in groups of 35 to 40 for discussion and quiz. Ninety-seven students in the lecture-quiz group were matched with 97 students in other classes meeting three times a week in groups of 35 to 40 on the basis of 4 criteria—sex, school of enrollment in the University, and the average percentile score on the Iowa Chemistry Aptitude Test, Iowa Mathematics Training Test, Purdue University English Placement Test, and National Council Psychological Examination. Achievement was measured in terms of objectively scored tests, daily written work, and an essay type of examination. Students' attitudes toward instructors and the method of instruction were also obtained. The major finding of the experiment is that the larger group under the lecture-quiz method did slightly but not statistically significantly better on the average than did the smaller recitation classes—this notwithstanding the fact that student attitude rather emphatically favored the less formal recitation method.

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*The Abstracts for the Section of Psychology were not received by the Secretary until the July number of the Journal containing the Proceedings of the Academy had been printed and was nearly ready for mailing.

The Anticipation of Correct Responses as a Source of Error in Learning Serial Responses.—By FREDERICK HILLIS LUMLEY, Ohio State University.

Forty subjects learned three maze patterns on a typewriter multiple choice maze These maze patterns consisted of two series of twenty letters and one series of forty letters Analysis of the types of errors showed that the subject anticipated responses which would have been correct further on in the series. The frequency of the anticipation errors was inversely proportional to the degree of anticipation Thus responses, which would be correct in the near future, were anticipated more often than responses which would be correct in the distant future As learning progressed the ratio of the near anticipations to the far anticipations increased. Analysis of the published data of other investigators shows this factor of anticipation.

The Effect of Emotional Stimuli on the Activity Level of the White Rat.—By JAMES R. PATRICK.

Two groups of fed rats, one rat at a time from each group, were put into an "activity maze" for a period of two minutes each. One group of ten rats constituted the control. The second group (10 rats) was the experimental group. The activity of the control group was recorded under normal conditions. But the experimental group was subjected to emotional stimuli during the full two minute period they were in the maze The results show that spontaneous overt activity, under the present conditions, is inhibited when rats are not operating under a drive but are confronted with emotional stimuli as is afforded by the sounding of buzzers. The control group, without the influence of emotional stimuli, showed 27 per cent increase in activity over the experimental group. Results from experiments reported in the literature seem to show that when the rat is operating under a drive, as in a learning situation, and when he encounters emotional stimuli that excess amount of behavior is shown. The present research, along with the others reported, indicates that the behavior level of the white rat is influenced by both "internal" and "incidental external" sources of stimulation while the rat is in the maze.

A Comparison of the High Relief Finger Maze and An Improved Form of the Stylus Maze.—By T. C. SCOTT AND B. B. NELSON, Ohio University.

The object of this investigation was to make a comparison between the high-relief finger maze and an improved form of a stylus maze. This stylus maze was so constructed that retracing was prevented. The stylus was also of such a nature that it fit snugly and the subject could not wander around in the groove or have the feeling of being lost.

One hundred subjects learned a stylus and a wire maze of identical pattern and size. Group 1 of 50 subjects learned the stylus maze the first day and the wire maze the second day. Group 2 of 50 subjects learned the wire maze the first day and the groove maze the second day. In both cases the subjects were not told that the patterns were the same. Group 1 required a few more trials and errors, but less actual running time, to learn the stylus maze the first day than Group 2 did to learn the wire maze. These differences, however, were highly unreliable, particularly in the case of trials and errors, the obtained difference between the means being less than the standard error of difference. The results the second day offered further evidence of this unreliability. About the same number from each group recognized the pattern the second day.

The relative difficulty of the respective alleys of the two mazes indicates that they are measuring the learning function in the same way. The correlation computed in terms of the total number of errors made on the respective alleys in the two mazes is .976.

The reliability coefficients were computed for the two mazes in terms of errors on the first ten trials and show the stylus maze to be somewhat superior to the finger maze for learning experiments.

Twenty-four subjects in each group of 50 were boys, giving sex groups of 48 boys and 52 girls. These two groups offer differences in favor of the boys which are more reliable than those existing between the two maze groups.

An Objective Study of Student and Faculty Attitudes Toward Academic Honesty.[1]—By C. O. Mathews, Ohio Wesleyan University.

It was the purpose of this study to discover the nature and variations of attitudes toward academic honesty among students and faculty members of a certain institution where an honor system had been functioning for about twenty-five years. As a means of tapping attitudes an objective blank containing thirty-six descriptions of honesty situations and one item concerning the reporting of observed dishonesty was constructed.

Responses from 494 representative college students show that there is an extremely wide variation in respect to the kinds of academic conduct that they can justify. There was not one situation of the thirty-six but that was justified by at least four per cent of these students. Only one item was unanimously agreed upon by the faculty.

The juniors and seniors ranked below the freshmen and sophomores in respect to their sense of academic honesty. Women exceeded men in all classes in this respect. There was a very wide gap between the opinions of the students and faculty. Both seemed to be more lenient in their attitude toward dishonesty in preparing assignments than in taking examinations.

In respect to reporting observed dishonesty only one-third of the students and two-thirds of the faculty justified it. Women were more favorable to reporting than men; seniors less favorable to it than the other classes; and those with the most favorable attitudes toward honesty were most favorable to reporting dishonesty.

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[1] This is a portion of a faculty report on the honor system at Ohio Wesleyan University. The members of the committee were Professors Diem, Lewis, Manchester, Murray and Mathews (chairman).

When honest opinions vary as widely as the ones expressed by these persons, and when rationalizations to justify most any action are so easy to construct, is it any wonder that honor systems seem ineffective and that the problem of academic honesty is always at hand?

Rating Scales in Industry.—By RICHARD STEPHEN UHRBROCK, Industrial Relations Division, The Procter and Gamble Company, Cincinnati, Ohio.

Four types of rating scales are most widely used in validating psychological and educational tests in industrial situations.

1. *Order of Merit:* Lists of names of persons to be rated are prepared and presented to judges. The judges are asked to rank the men from best to poorest, and to indicate their ratings by numbering the names.
2. *Man-to-Man:* Traits are defined. A master rating scale is prepared by each judge, who lists the names of persons known to him who possess, in varying degrees, the qualities to be rated. New men are compared with the well-known individuals whose names appear on the master scale. Numerical values are assigned to points on the scale
3. *Graphic Rating Scale:* Traits considered essential for success on a given job are defined. Degrees of the traits are indicated by means of descriptive phrases. Judges are asked to check the items that most clearly describe the behavior, or attributes, of the man being rated. Each step on the scale is given a numerical value.
4. *Paired Comparison:* The name of each man to be rated is paired with the name of every other man in the group under consideration. Judges are asked to check the name of the better man in each pair.

With ratings upon each man in a group, obtained by means of one or more methods, it becomes possible to rank the members of the entire group under consideration, and to isolate the best third, and the poorest third, for detailed study.

Scientists and Church Membership.—By HARVEY C. LEHMAN AND PAUL A. WITTY, Ohio University and Northwestern University.

In this paper tables are presented which set forth the percentages of individuals from several branches who stated their church affiliations when writing their autobiographical sketches for *Who's Who in America*. Some interesting age differences are presented also.

The names of the most outstanding scientists in the United States were obtained from the 1927 edition of *American Men of Science*, the biographical directory edited by Cattell. Data regarding church membership were obtained from the 1926-1927 edition of *Who's Who in America*.

It is possible that these data indicate also the relative seriousness with which various types of scientists take their church membership. If the latter conclusion be valid it is clear that the physicists consider church membership most seriously; the physiologists, the psychologists, and the anatomists, less seriously, and that older scientists look upon religious denominations less seriously than do younger ones.

The more plausible explanations (from the authors' points of view) are also presented.

The Mental Status of Reformatory Women.—By C. H. Growdon, Ohio Bureau of Juvenile Research.

This study reports the results of a mental survey covering a five-year period beginning July 1st, 1925. The total number of prisoners examined during this time was 2185, of whom 70 were discarded because of unsurmountable language difficulties. Of the number examined 1312 were white adult women, of whom 432 were felons, and 880 misdemeanants. The negro population was 803, of whom 226 were felons, and 577 were misdemeanants.

The method of examination was that of group tests of three varieties, namely, general intelligence tests (Army Alpha, or Morgan's Mental Test), performance tests (Pintner Non-language Tests) and literacy tests (Ohio Literacy). These were supplemented by interviews and individual tests whenever there was good reason to doubt the accuracy of the ratings obtained by group examination. After each prisoner had been given the battery of three group tests the mental ages thus obtained were combined into a single mental age rating by a process of weighting which gave the general intelligence test a weight of two points, the literacy and performance tests a weight of one each in a scale of four.

The mental ages of the prisoners were then grouped together into frequency tables showing the distribution according to race, and crime committed. These distributions were then compared with the mental age norms established for the general population of each race by the army psychologists during the World War. (There are no comprehensive mental age norms for the general female population. We assume that they would parallel those for men had they been established.)

In addition to the comparison on the basis of mental age distributions a more direct estimate of the relationship between imprisonment and mental level was obtained by calculating a "prison ratio" for each mental age, and for each variety of crime. This ratio is obtained by dividing the percent of frequency of any given mental age as found in the population at large, by the percent of frequency found among prisoners at the same mental age. The results are presented in a series of tables and curves.

The main conclusions reached are as follows:

1. On the basis of median mental ages, white female prisoners rated approximately 2.0 years lower than the general white population. White felons gave a median mental age of 11.26 years, white misdemeanants gave a median of 10.02 years.

2. On the same basis negro prisoners rated 1.45 years lower than the general negro population. Negro felons gave a median mental age of 8.65 years, negro misdemeanants gave exactly the same median.

3. On the basis of smoothed percentile curves, the median mental ages rate the prisoners convicted of various crimes thus in decreasing order of mentality:

White prisoners: Forgery and embezzlement, grand larceny, petit larceny, murder, burglary, sex offenses other than prostitution, robbery, prostitution, contributing to delinquency and dependency, violation of the liquor laws, and various types of assault.

Negro prisoners: Forgery and embezzlement, petit larceny, prostitution, grand larceny, contributing to delinquency and dependency, murder, violation of the liquor laws, various types of assault, robbery, sex offenses other than prostitution, and burglary.

4. The prison ratios show that, for both races, the mental ages from six to ten years send in a relatively high excess of prisoners, that fewer than the expected number come from the mental levels of eleven to fourteen years, and that at fifteen and sixteen years there is a tendency to increase beyond the ratios set by the mental ages of eleven to fourteen. In the case of white prisoners below the mental age of ten years the prison ratios vary from 1.76 to 9.00 times as many in prison as in the general population. In the case of negroes the prison ratios at these same ages seldom exceed 1.5 times the rate in the general negro population.

5. On the basis of prison ratios it appears that mentality is a much greater factor in the conviction of white female delinquents than in the case of negroes, and that persons of average intelligence are less liable to conviction than those higher or lower than average.

Some Recent Findings in the Part and Whole Methods of Learning.—By C. C. Wood.

The investigation from which the following report is taken was prompted by the old quarrel which started more than thirty years ago and which still rages. Steffen, Pyle, Snyder, Freeman, Dolan, Pechstein, Reed, Brown and others have all made substantial contributions.

Most of the investigators named above have found the whole method superior to the pure part method or to any of the modified part methods. Pechstein and Reed are two of the outstanding supporters of the part method of learning. In the light of these investigations the writer set out about three years ago to satisfy, as far as possible, his desire for first hand information concerning this matter of learning.

Ten University students, five men of graduate rank and five undergraduate women, served as subjects. The material for learning consisted of fifteen series of nonsense syllables, twenty-four syllables to the series.

Five methods were used, the pure part, the whole, the progressive part, the direct repetitive and the reverse repetitive. The methods were so rotated that the effects of practice were duly equated, taking care of the transfer effect of each subject's first learning upon the following series.

THE EFFECTS OF PRACTICE ON THE RELATIVE EFFICIENCY OF WHOLE AND PART METHODS.

Our primary interest just now is in the effects of practice on the relative efficiency of the various methods.

There are several problems involved in the general effects of practice. They are (1) Individual differences (2) the effects of choice of criterion (3) the factors conditioning improvement. We wish to answer three questions which may be stated here; they are:

(1) Does practice accentuate or minimize the difference of methods?

(2) What are the relative amounts of change in the efficiency of the various methods?

(3) To what extent is there correlation between the values of the methods?

In answer to the first question our data indicates that practice minimizes differences, in many instances bringing them almost to the vanishing point. For example the difference in trials between the best and poorest methods, in group I, decreased, from the first to third round, 60.5 per cent, for group II, the decrease was 17.6 per cent between the first and second rounds.

In errors, these decrease in differences were respectively, 65.8 per cent and 34 per cent.

In time, these decreases in differences were, respectively, 91 per cent and 30 per cent.

In answer to the second question our data shows that in every instance the method that was least effective in the beginning showed the greatest improvement and in every instance save one, the method that was most effective in the beginning showed the least improvement.

In the matter of question three, our data shows that correlation became less perfect as practice proceeded.

After the first round, the three criteria give results which were decidedly out of agreement.

Measured by all criteria the effectiveness of the methods ranks as follows:

1. Direct Repetitive.
2. Progressive part.
3. Reversed Repetitive.
4. Pure part.
5. Whole.

In finality the writer wishes to say that the limits of improvement were not reached for any method in this investigation.

How long improvement can continue or just what the limits of improvability are, is a matter of individual capacity. Until the limit of efficiency is reached, improvement is possible. The writer believes that the feeling of necessity has goaded the subjects into a more intensive effort to excel by the whole method procedure than by the part methods. It is therefore possible that the whole method is as near or nearer the limit of efficiency as any of the part methods.

Collection of "Progress" Indices for Ohio Counties.—By C. W. Hall.

In an effort to obtain a measure of the economic, social, educational and health status of each Ohio county, data concerning 157 variables have been collected. These data have been converted into indices. A few of these indices are: percentage of farms located on hard surface roads, tuberculosis death rate, birth rate, percentage of homes having telephones, per capita wealth, per capita sale of Red Cross stamps, average intelligence of high school seniors and the average experience of teachers. From this large group of indices, the best indices for predicting school success will be selected. The variables thus selected will be combined into an index which will be used to secure a socio-economic rating for each Ohio county.

The paper points out many difficulties encountered in using the statistics collected by the several state departments. The most serious errors are introduced by (1) the arbitrary determination of community limits in terms of political units (2) the impossibility of using the same units for all variables (3) the registration in one community of statistics that actually pertain to another community, and (4) the lack of adequate checks. These difficulties seriously impair the usefulness of much of the data gathered by the state. It is suggested that this situation could be remedied, at least in part, by the appointment of a state director of statistics charged with the improving of techniques and coordinating the work of various state statistical divisions.

The Effect of Hypnosis on Long Delayed Recall.—By JOHN M. STALNAKER, Purdue University.

Twelve subjects in recalling 92 selections of prose or poetry learned a year or more before, were able to reproduce on the average 67 per cent more in the trance than in the waking state. A practice effect of 14 per cent increase of the second condition over the first was found, although a counterbalanced order prevented this from influencing the final results. The subjects were found to improvise the poetry where their literal memory proved inadequate, to a greater extent in the trance state.

The Effect of Rhythm and Reverie on the Machine Worker —By STANLEY B. MATHEWSON.

This paper discusses what the machine is doing for the human—doing for him emotionally, not economically.

Machine workers whose jobs permit the establishment of rhythmical bodily motions soon experience a "mind freedom" which permits protracted reveries. Such reveries are often pleasurable mental excursions which leave the worker in an emotionally quiescent state. The triple combination of (a) response to measured cadence, (b) day dreaming, and (c) earning one's living, accounts for great masses of human beings remaining contented year after year at work which requires only muscular attention. Bodily response to rhythm, and mental tendency to day dream, are among the oldest habits of man. When a human being engages in age-old customs, a sense of satisfaction usually accompanies such acts.

Machine made reveries may consist of nothing more than idle and fanciful musings or even morbid worries. On the other hand, they may be meditations of great merit. Samuel Gompers and Michael Pupin are examples of men who planned great things while they were still uneducated routine workers and later in life made imperishable contributions in their respective fields Each in his autobiography clearly traces such deeds to the "mind freedom" permitted by certain work in their early lives. A number of other cases of reveries on the job are cited, among them being the experiences of the investigator himself while a conveyor worker at the Ford Motor Company plant.

The paper concludes with the suggestion of further research into the possibility of directing the mind habits of rhythmical workers into more generally constructive channels.

The Check-list as an Instrument to Determine Personality Changes in Pre-school Children.—By W. G. PIERSEL, Marietta College.

The check-list used was devised by Dr. Elizabeth Moore of the Iowa Child Welfare Research Station, State University of Iowa. The activities, briefly stated, are these:

1. Shows alert curiosity.
2. Tries to mold environment to his purpose.
3. Finds interesting occupation.
4. Creates or constructs.
5. Plans definitely.
6. Exerts efforts at continued difficulty.
7. Gives sustained attention.
8. Faces issues frankly.
9. Rises to meet occasion.
10. Shows stability at changes in environment.
11. Speaks with cheerful, well-placed voice.
12. Shows self-control when mentally or physically hurt.
13. Shows composure at interference from others.
14. Sees humorous aspect of situation.
15. Shows ability to care for own needs.
16. Speaks and acts with directness and effectiveness.
17. Welcomes and uses help and advice.
18. Adjusts to social needs or order.
19. Shows kindness to others.
20. Shows healthy direction of affections.
21. Respects the rights of others.
22. Converses with others.
23. Shows sensitiveness to approbation.
24. Seeks companionship, responds to friendly advances.
25. Enters into cultural experiences.

Taking Phyllis as an example, six observations of fifty minutes each were made, and after checking, were divided into two equal parts, the first three coming early in the period, and the last three much later. A comparison of the scores in the two periods indicates certain positive changes in personality, such as increasing stability at changes in environment, more definite planning, giving sustained attention, and more seeing of the humorous aspect of things. A large increase in disobedience to adult requests is noted, which tends with the other changes to show increased capacity for self-direction. With added familiarity to the pre-school situation, she talks much more, expressing more ideas, and shows less tendency to seek the companionship of others.

Some Comments on the Interrelations of Intelligence Test Score, Stated Intention of going to College and Occupational Choice of High School Seniors.—By HAROLD A. EDGERTON, Ohio State University.

The data presented are from the study of over 30,000 Ohio High School seniors in the autumn of 1930. The following may be briefly noted:

1. There is some relation between an intelligence test score (Form 17, Ohio State University Psychological Examination) and stated intention of going to college.

2. There is too little differentiation between low scoring and high scoring pupils as regards intention of college attendance.

3. There is some relationship between the occupation which the pupil expects to enter and his test score. Such occupations as author, chemist, lawyer, physician, are chosen mainly by high scoring pupils; and occupations such as farmer, beauty parlor operator, machinist, carpenter are chosen by those of lower test score.

4. The data give some notion of the sort of intellectual competition the pupil will have to meet in entering the various occupations.

5. Most of the girls who have expressed an occupational preference, wish to enter one of three occupations: teaching—precollege (1851), nursing (1751), and stenography (2485).

6. The data, which have so far been studied, indicate that much time in high school should be spent in the guidance of:
   (a) Girls generally.
   (b) Boys and girls whose parents are not professional people.
   (c) Girls who have decided to go into elementary or secondary teaching, stenography or nursing.
   (d) Boys and girls who have not yet decided regarding college, particularly the brilliant and scholarly.
   (e) Brilliant and scholarly boys and girls who have decided against college attendance on financial grounds.

PHYSICAL SCIENCES SECTION.

The Lecture-Demonstration and Individual Laboratory Methods of Introducing College Students to First Year Chemistry.—By C. C. Ross, University of Kentucky, and V. F Payne, Transylvania College.

The study here reported involving twelve sections of first year college chemistry students in four institutions has not produced uniformly significant results. The writers have concluded, however, on the basis of several methods of comparison, the number of students used and the number of colleges and instructors involved, that these students made better progress, as that progress is commonly measured, when introduced to the study of college chemistry by the lecture-demonstration method. Likewise they have concluded that the students of lesser ability profited relatively more by the introduction through lecture-demonstration than did the students of greater ability. Also there were indications that later work by the individual laboratory method is strengthened by the lecture-demonstration introduction.

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GLACIATION OF NORTHWESTERN HOLMES COUNTY, OHIO.*

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INTRODUCTION AND ACKNOWLEDGMENTS.

In a part of Ohio the Wisconsin ice sheet advanced into a region of considerable relief, up to and just over the main preglacial divide. The effects of glaciation on a region of deep valleys, the character of the glacial boundary, and the deposits—especially the kames and kame terraces in the valleys—will be described in detail. The geology—stratigraphic, economic, and glacial—of all of Holmes County has been studied, but this paper is concerned with the glaciation of the northwestern part, because the glacial phenomena of a hilly region are well developed here. Northwestern Holmes County is bounded on the north by Ashland and Wayne counties and on the west by Ashland County. This area lies in Washington, Ripley, and portions of Knox and Monroe townships, and is shown on the Loudonville quadrangle of the United States Geological Survey. The areal map accompanying is drawn on a portion of that sheet.

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*Published with permission of the Director, Geological Survey of Ohio.

To Mr. Wilber Stout, Director of the Geological Survey of Ohio, I am deeply indebted for co-operation and helpfulness at all stages of the investigation of the geology of Holmes County, and I take this means of expressing my sincere thanks and appreciation. My wife has helped in the preparation of the manuscript for which I am grateful.

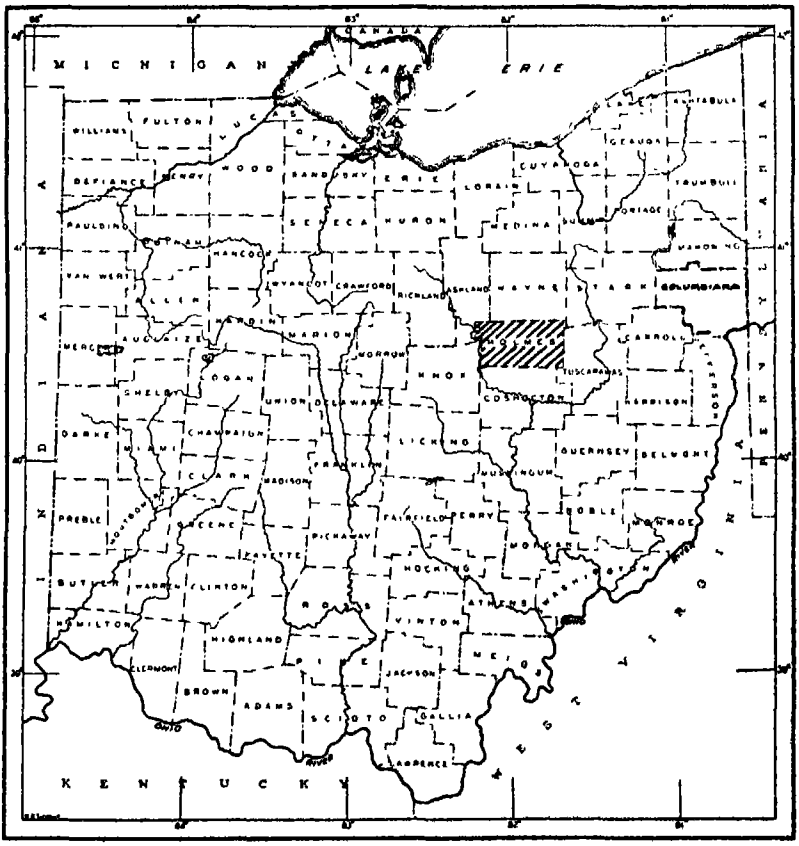

FIG. 1. Index Map.

DRAINAGE.

Except for a small southern portion of this area which is drained by small streams directly tributary to the Mohican River or tributary to Black Creek, several miles south of the glacial boundary, most of the area is drained by Lake Fork of the Mohican River and its tributaries. Lake Fork, formed by the junction of Jerome Fork and Muddy Fork in Mohican Township, Ashland County, flows in a general southerly direction through Lake Township, Ashland County and Washington Township, Holmes County and joins the Mohican River in the south part of the area near the Washington-Knox township line. The stream's present course is post-glacial. The preglacial drainage was by a large stream flowing east in a wide valley which has been traced from Wooster to Shreve, thence across northern Washington Township, Holmes County, to Loudonville, and on to the northwest.* This abandoned valley is spoken of by Leverett† as the "old Mohican" and will be referred to as the *preglacial Mohican* in the present report.

The valley of the present Lake Fork is made up of two parts. The first is that of a preglacial stream which rose in Mohican Township, Ashland County, and joined the valley of the preglacial Mohican at the Ashland-Holmes county line.‡ The other, and lower portion of the present valley was formerly occupied by a small stream flowing north from the southwestern part of Washington Township, Holmes County, to the valley of the preglacial Mohican in Section 33 of the same township. It is possible that this preglacial stream swung to the northeast in central Section 4 and entered the large valley in Section 34. A wide depression, partially drift filled is present here. This depression was the course of escape of considerable melt water from the ice

With the coming of the glacier, the preglacial Mohican was dammed, the waters extended up the tributary valleys to the south, and escaped over low places in the divides, thus forming the present Lake Fork and Black Fork. It is possible that this diversion of the drainage took place in pre-Wisconsin time. Because of the narrowness of the valleys, it is thought that the formation of the present Black Fork and Lake Fork of the Mohican River did not take place earlier than Illinoian time.§ Other and smaller streams were also deranged by glaciation. Sigafoos Run, which formerly flowed north from northern Knox Township and entered Lake Fork (reversed) in Section 4 of Washington Township, was a larger stream than preglacial Lake Fork south of the preglacial Mohican. Sigafoos Run, where it leaves its old valley, flows directly west across a low place in the hills and enters the Mohican River just below the mouth of Lake Fork. This postglacial portion, about a mile in length, is a deep narrow gorge just at the glacial boundary.

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*Todd, J. H., Preglacial Drainage of Wayne and Adjacent Counties: Ohio Academy of Science, Special Papers, No. 3, pp. 46-67, 1900.

Ver Steeg, Karl, Drainage Changes in the Vicinity of Wooster, Ohio: Ohio Jour. of Science, Vol. 30, pp. 309-314, 1930.

†Leverett, Frank, Glacial Formations and Drainage Features of the Erie and Ohio Basins: Mon. 41, U. S. Geol. Survey, p. 164, 1902.

‡Hubbard, G. D., Stream Diversion near Lakeville, Ohio: Ohio Naturalist, Vol. 7, pp. 349-355, 1908.

§Killbuck Creek, which flows south through a wide valley in the central part of Holmes County, is believed to have been forced into its present course by some ice sheet earlier than Illinoian. The features of this valley will be discussed elsewhere.

RELIEF AND ITS EFFECT ON GLACIATION.

The main reason for the difference between the deposits in this portion of Ohio and those in other parts of the state is the relief of the region into which the ice sheet advanced. The country immediately to the north of the glacial boundary could not have been markedly different from that to the south.

The region in general is a plateau in early maturity. Flat areas, remnants of the Harrisburg peneplain,* remained on the divides at an elevation of approximately 1,220-1,240 feet. In northeastern Knox, southwestern Ripley, and northwestern Monroe townships the ridges, along the main preglacial divide mentioned by Coffey,† are about 100 feet higher, with monadnocks above the general level reaching to almost 1,400 feet. The elevation of the rock floor of the preglacial Mohican varies from 835 feet at Loudonville to 801 feet at Lakeville.‡ The present altitude of the abandoned valley, now partially filled with drift, is from 920 to 1,000 feet.

Glacial features dependent on the ice advance into such a terrain have been studied in Holmes County, and the area described shows these at their best development. They have been seen by the writer in Knox, Ashland, Wayne, and Richland counties, and probably are to be found to some extent in the other hilly portions of Ohio into which the ice advanced. It is hoped that further detailed work in the hilly regions east and west of Holmes County will extend our knowledge of this type of deposit.

Because of the relief of the region, several factors affected the work of the last ice-sheet near the glacial boundary:

1. Difficulty of ice advance.
2. Reversal of streams in valleys already formed, but no (or little) cutting of new valleys, except across divides to enter another valley.
3. Preservation of the major features of the preglacial topography.
4. Uneven melting and retreat of the ice front, with little forward motion during retreat and with many blocks and masses of ice left behind.

1. Obviously, if the glacier had to advance over an uneven and rugged surface, the rate of advance would be less than if it had a fairly level surface over which to move. Probably this accounts for the fact that none of the continental glaciers advanced as far in eastern Ohio as they did in the central and western part of the state.

2. If the glacier advanced over a reasonably level surface, the major valleys would probably be filled with drift, and upon melting of the ice, the streams would be forced to make new valleys and channels for themselves, which would seldom coincide with previous stream courses. On the other hand, if the glacier advanced over a region of

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*Stout, Wilbur, and Lamborn, R. E., Columbiana County: Geol. Survey of Ohio, Bull. 28, p. 38, 1924.

†Coffey, G. N., Preglacial, Interglacial and Postglacial Changes of Drainage in Northeastern Ohio with Special Reference to the Upper Muskingum Drainage Basin: Ohio Jour. Science, Vol. 30, map p. 375, and p. 377, 1930.

‡Todd, J. H., Preglacial Drainage of Wayne and Adjacent Counties: Ohio Acad. Sci., Special Papers, No. 3, pp. 46-67, 1900.

marked relief, such as the one under discussion, and did not fill the valleys with drift, the streams on their reappearance after (and during) the melting of the ice, would find it easier to flow in valleys already present. The direction might be reversed and cols from one drainage system to another might be cut through low divides, but in large part the valleys would be preglacial.

3. The preservation of the major features of the preglacial topography in northwestern Holmes County and in other hilly portions of Ohio near the glacial boundary is due not only to the relief of the land over which the glacier advanced, but also to the fact that the advancing glacier was nearing its farthest extent and was hence undoubtedly thinner and much more sluggish than in its advance over the territory to the north. Although the territory to the north may have had less relief originally, the glacier being more active there was able to subdue the topography to a far greater degree than it was that farther to the south.

As detailed descriptions, which will be given later, show, the lowland is more or less covered with thick drift deposits. The high land, on the other hand, is in most places covered with a sheet of till, which is described as gound moraine As a general rule, the higher the ridge the thinner the till. On some of the hilltops the till is thin or absent and the bedrock is exposed The small amount of glacial erosion or deposition on the uplands is shown by the fact that the Harrisburg peneplain remnants are concordant on both sides of the glacial boundary. The gross form of the hills is preglacial

The preglacial valleys are a dominant factor of the present topography. Some now carry streams; some do not. Not only are the major valleys of preglacial times still evident, but many of the smaller valleys seem to be of preglacial origin

4. The glacial deposits in the valleys are the most noteworthy features in this area. These valley deposits are not of the usual valley train type which have been dissected by later stream erosion. They are deposits laid down by melt water around, between, and over blocks and masses of ice left behind in the valleys after the main ice front had melted back to the north. In some cases the stratified deposits were laid down in temporary lakes, but in most they seem to have been deposited by running water. Stagnation of the ice sheet, as postulated by Flint* in Connecticut, is not thought to have occurred in a very large part of Ohio. Near the glacial boundary, however, and in fact in this whole area, once the ice had advanced to its farthest extent, very little forward motion as the ice melted away, was present. The glacier near the ice front melted away in a ragged fashion leaving behind blocks and masses of ice where it had originally been thicker, namely, in the valleys. When the ice had advanced to its farthest extent, the ice front and that part of the ice directly back of the ice front, must have been thin on top of the ridges, as shown by the little erosion and small

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*Flint, R. F., The Stagnation and Dissipation of the Last Ice Sheet: Geogr. Rev., Vol. 19, pp. 265-289, 1929.
Flint, R. F., Glacial Geology of Conn: Conn. State Geol. and Nat. Hist. Survey, Bull. 47, 1930.

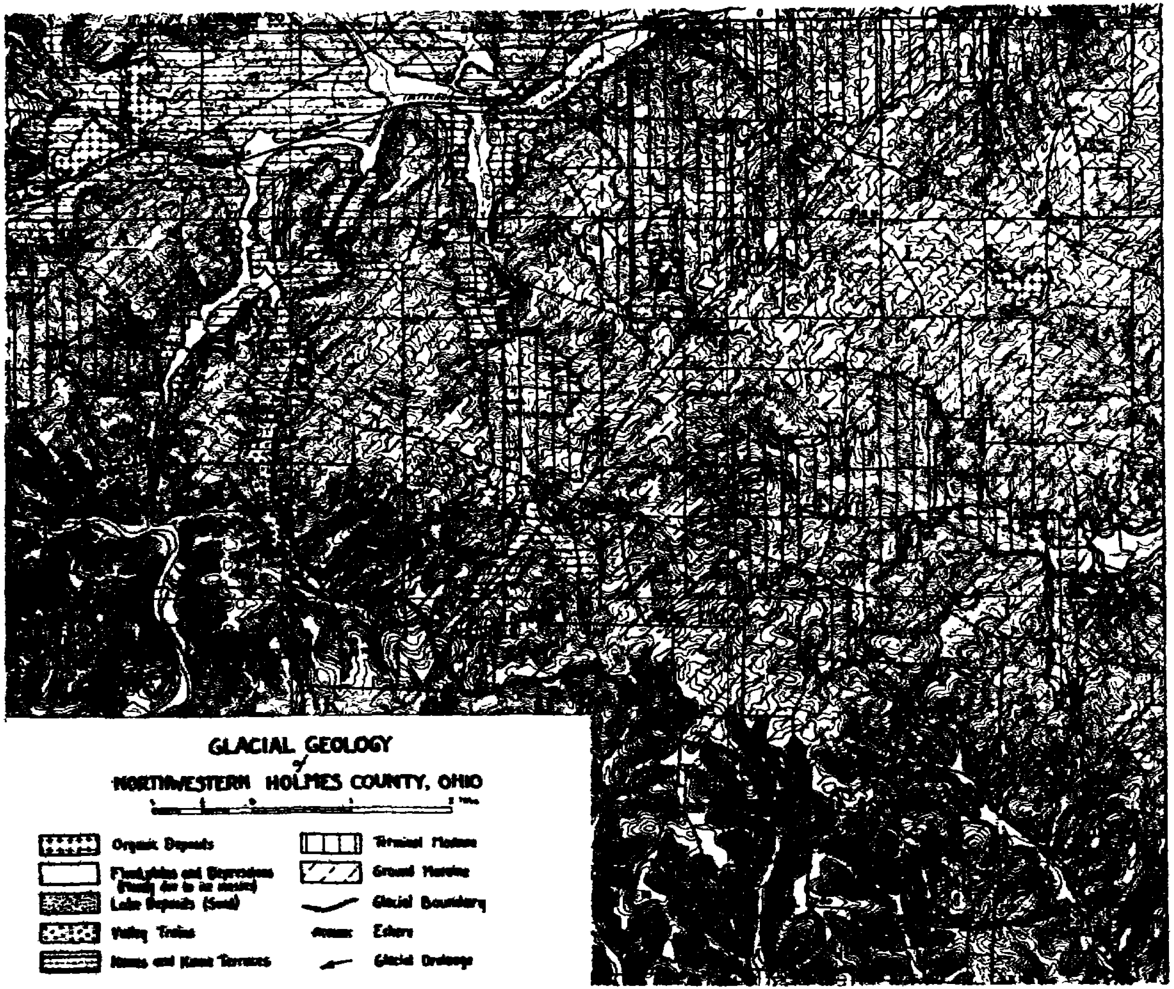

FIG. 2. Map of Northwestern Holmes County, showing Glacial Deposits.

amount of deposition there. The present valleys are from 200–300 feet deep, and if the thickness of the valley filling is added, they were from 100–200 feet deeper when the ice advanced into the area. Therefore, it is believed that when the ice melted away, it melted from the hilltops first, exposing the hills and ridges while ice still remained in the valleys, and that across this area there was no definite ice front at any time during the melting away of the glacier. The deposits in the valleys are such as would be deposited from and around these detached masses of ice remaining.

GLACIAL BOUNDARY.

The Wisconsin glacier advanced into Holmes County, reaching the top, and pushing slightly over the top of the main divide that runs in a general east-west direction across the county. This preglacial divide and the higher land near it was one of the factors which allowed the ice sheet to go no farther. From east to west the drift border runs one-half mile south of the village of Winesburg, southwest to just south of Berlin, crossing the valley of Doughty Creek at Wise School two miles south of Berlin, thence in a winding manner to Killbuck Creek at the junction of Sand Run with that stream one and one-half miles south of Millersburg. From Killbuck Creek the boundary is due west across western Hardy Township and eastern Monroe Township, crossing the valley of Shrimplin Creek three-fourths of a mile south of the hamlet of Welcome. One mile west of Shrimplin Creek it turns to the northwest across southwestern Monroe Township, crossing Bell Ridge three-fourths of a mile north of Bell Ridge School, passing just south of the top of the 1,400 foot knob two miles south of Nashville, and extending in an undulating fashion to Sigafoos Run in southwestern Section 22 in Knox Township. From here it follows Sigafoos Run to the junction of that stream with the Mohican River and thence in a westerly direction across the southern edge of Washington Township to the Holmes-Ashland county line. It passes about two miles south of Loudonville, just south of the Turkey Ridge School in Hanover Township, Ashland County.

Along the glacial boundary in Monroe, Knox, and Washington townships, topography and deposits, which are definitely of terminal morainic character, do not approach closer than two miles to the boundary except in the valleys, and at one place near Loudonville. The statement by Leverett* that "drift knolls with their fresh topography continue right up to the glacial boundary" and of Wright† that the boundary "line is very sharply defined", is true only in some of the valleys, especially those of Killbuck and Doughty creeks, in the central and western part of Holmes County.

Thick drift deposits are not found on the hilltops and ridges within a half mile, and in some cases a mile, of the boundary. Approaching the boundary from the north in marking it out on the map, one passes from thick drift to thin drift, thence to discontinuous drift on this preglacial divide, and then into a region where the bedrock is at the surface and one finds only a few scattered foreign boulders. The farthest southerly extent of these scattered boulders has been taken as the limit of the Wisconsin ice advance. The deposits within a mile or more of the glacial boundary cannot be spoken of as a terminal moraine. Furthermore, those so called terminal morainic deposits closest to the glacial boundary are, as will be explained later, associated with low places in the surface and are not due to their proximity to the limit of glaciation. Valley deposits, such as the one in Lake Fork valley, are not morainic, although they have a knob and kettle topography, but are kame-like deposits South and southeast of Loudonville along the Ashland-Holmes county line, morainic topography and deposits are found on the upland, the only place in the area where such is the case. Even here a belt almost a mile wide, in which the drift is thin and not morainic in expression, is found between the definite moraine and the glacial boundary

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*Leverett, Frank, Glacial Formations and Drainage Features of the Erie and Ohio Basins: Mon. 41, U. S. Geol. Survey, p. 390, 1902.

†Wright, G. F., The Glacial Boundary in Western Pennsylvania, Ohio, Kentucky, Indiana, and Illinois: Bull. 58, U. S. Geol. Survey, p. 60, 1890.

The character of the marginal deposits is well shown along Bell Ridge which runs north and south in eastern Knox Township a little less than a mile west of Monroe Township At Stones School, one and one-half miles south of Nashville, the drift is thick and bedrock is not visible As one goes south from Stones School the drift continues thick for about a half mile. From this point onward the drift becomes notably thinner until about a mile south of Stones School it seems to end. However, as one progresses along the road and through the fields an occasional igneous boulder from one to two feet in diameter may be seen for about three-eighths mile to the south. The thickness of the drift south of Stones School is well shown where the Middle Kittanning coal is being stripped from the top of the ridge on the Wallace Bell farm. The overburden taken out by the steam shovel shows the material to be residual and not glacial soil. The boulders, never very abundant, become fewer and fewer until, a little more than a mile south of Stones School, no more boulders were observed beyond a line three-fourths of a mile north of Bell Ridge School. The glacial boundary was mapped at these last foreign boulders which were seen along the ridge top

The same situation is found along the north-south ridge in western Monroe Township about a mile east of the Knox Township line.

One of the points of easiest accessibility, where the transition may be seen of the thick drift to the thin drift, of the thin drift to the discontinuous phase, and hence to the scattered boulder phase at the glacial boundary, is along the gravel road running south from Loudonville toward Spellacy, in Section 12 and Section 13 of Hanover Township, Ashland County. As one climbs onto the upland south of the Loudonville corporation limit, one crosses a morainic area which will be described later. The drift here is quite thick. At the line between Section 12 and Section 13 of Hanover Township the morainic area gives way on the south to a ground moraine area which is much flatter and less hummocky than the morainic area to the north. A quarter of a mile south of this section line the drift is thin. The bedrock can be seen in the road ditch overlain by from two to four feet of till. One-half mile south of the section line the drift is so thin that the bedrock appears at the surface and no more till is seen. For about three-eighths of a mile, however, along the ridge traversed by this road, an occasional foreign boulder is present. Where the road crosses the county line the last foreign boulders were observed.

Two factors may be responsible for the thin edge of the drift deposit in this area. *First*, the ice front as it advanced up to and just over this main divide was undoubtedly quite thin and was not capable of carrying very much material. Apparently at its farthest extent the ice edge did not remain stationary for any length of time; rather it seemed to advance to the point of farthest extent and immediately draw back. Under such circumstances it is quite likely that little in the way of deposit could be made. On the northerly slopes of this main east-west divide the ice edge remained for a longer time and consequently the drift is thicker

Second, this main divide of which these north-south ridges are spurs, is dissected deeply by southward flowing streams In the valleys of these southward flowing streams little or no drift can be seen. The southerly slope of this divide may have been cut into by post-glacial erosion of the southward flowing streams working back to the north by headward erosion In such a case any deposits would be removed from the valleys and the only remnants would be on the divide and ridges. Where the ridges are not very flat-topped, the material might creep and slide into the valleys and be removed by erosion. This factor is not thought to have been nearly so important as the first mentioned.

It might be noted in this connection, that the valleys of southward flowing streams in western Monroe and Knox townships, which head at the glacial boundary or beyond, (Shrimplin Creek excepted) contain little or no outwash material. Extended search of these valleys was made, and beyond an occasional granite pebble, no material, which could be identified as glacial outwash, was found. Probably these valleys originally had very little outwash material and postglacial erosion has removed that little.

It may be noted in this place that the Illinoian glacial boundary, which is supposed to extend south from a point one and one-half miles south of Nashville to the Walhonding River,* was not found. Indeed, in western Knox and Richland townships of Holmes County, supposed to have been covered by the Illinoian ice, no indication of glacial deposit of any age was seen. Neither was such indication seen in northeastern Jefferson Township, Knox County, nor in southeastern Hanover Township, Ashland County.

DEPOSITS.

The deposits left by the ice may be divided into two groups: till, or unstratified drift, and stratified drift. Till was deposited directly by the ice as it advanced over the region, or was dropped when the ice retreated. The stratified deposits were laid down by water flowing from the melting ice, depositing material in glacial streams or lakes.

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*Leverett, Frank, Mon. 41, U. S. Geol. Survey, p. 225, 1902.

Unstratified Drift.

The unstratified or till deposits are of two kinds: ground moraine and terminal moraine. The distinction is based on surface expression. The ground moraine is only slightly undulating, and is said to have a "weak" expression, whereas the terminal moraine has a "stronger" surface expression.

The Ground Moraine.

The upland surfaces and higher hill slopes are covered with boulder clay or till which is called the ground moraine. The average thickness of the till in this area is hard to arrive at because on some of the hilltops, especially near the glacial boundary, the till is absent and in other places, several miles to the north of the glacial boundary, especially over most of Ripley Township, the till may be 50 feet or more in thickness. The average thickness of the till in Wayne County to the north and northeast is 20 feet.*

The material making up the till was carried by the glacier from the north and deposited, both as the glacier advanced, when the material was sloughed off the heavily loaded lower part of the ice, and when the ice melted away. It was deposited with little or no sorting by running water from the melting ice. The ground moraine is divisible at some outcrops into two parts: a lower, more clay-like, compacted part; and an upper, more gravelly, loose part. These were called long ago by Upham† the "lower till" and the "upper till." The lower till, which is the thicker, is believed to have been deposited as the ice advanced and hence was packed down by the weight of the ice over it. The upper till was thought to have been deposited as the ice melted back and some water sorting is evident at places. This division of the ground moraine into an upper till and a lower till is better shown in the glaciated parts of central and eastern Holmes County and will be described more fully elsewhere.

The till is a sandy or silty clay, with many fragments of rock which are subangular and sometimes rounded. The size of these fragments varies from silt and sand grains to pebbles and boulders which may be 4 feet or more in diameter. The material of the till is largely of local derivation. It was derived mainly from shaly Waverly (Mississippian) sandstone which is the bedrock of most of the region‡ and of that to the north over which the glacier advanced to reach this position. Mixed in with the silt and Waverly sandstone fragments are pebbles, cobbles, and boulders of igneous and metamorphic rocks which were carried down from the north of Lake Erie. These foreign boulders and cobbles do not make up nearly so large a proportion of the whole as they appear to do when an outcrop is first seen. When any given till bank is examined closely the percentage of foreign material is seen to be small. Most of this till, therefore, was carried but a short distance—but a few miles—and most of it is believed to have been carried less than 25 miles.

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*Conrey, G. W., Wayne County: Geol. Survey of Ohio, Bull. 24, p. 32, 1921.

†Upham, Warren, Chapter in Hitchcock, C. H., Geology of New Hampshire: Vol. 3, pp. 285-287, 1878.

‡Some lower Pennsylvanian layers are found on the higher hilltops. These are mainly sandstone. Near Nashville the rocks are as young as Allegheny.

Near the top the till is buff or yellow in color. Where fresh exposures are seen, the lower part is usually bluish-gray. This is due to the unoxidized character of that more deeply buried. Both the yellow and the blue till are believed to have the same origin, the yellow having been oxidized, the blue not as yet oxidized. The depth of oxidation is variable, depending on permeability of the till, and slope of the land. Clear exposures, where slumping has not yet had a chance to occur, are rare and a definite average for the depth of oxidation of the till is not attempted.

The till is believed to cover the entire surface, but in the valleys it is concealed by later stratified deposits. The thickness of the ground moraine in the valleys is not known. How much of the valley filling is made up of gravel deposits, and how much is underlying till, is undetermined. Well records are not kept in sufficient detail so that the filling can be differentiated into gravel and till.

The topography of the ground moraine is somewhat variable. In general, the deposits were plastered on ridge tops or ridge sides. In many places the surface is smooth (not necessarily level) and does not undulate, so that very little suspicion of glaciation would be created in anyone's mind examining this area of weak expression for the first time. At other places, the ground moraine is somewhat billowy and grades with some intermediate stages into a hummocky topography, having a stronger expression, which is mapped as being topography of terminal morainic type. This will be treated under a separate heading below.

In northwestern Monroe Township the topography of the ground moraine is only slightly undulating, the undulating character increasing to the north in the valleys. In the valley of Paint Creek hillocks of drift cause a morainic topography.

In southern Ripley Township north of Paint Valley, in the region of Hopewell Church, the uplands are very heavily drift covered. Practically no bedrock is visible in this township. The till is quite thick; 25 feet or more may be seen in many places. The uplands here are gently undulating, but only a slight suspicion of sag and swell topography is present. Here the till is sandy in the upper part with the lower part more clay-like. The drift is only moderately stony with few stones over 6 inches in diameter. An occasional boulder up to 3 or 4 feet may be seen in the fields. This is the territory in which some of the finest farming land of Holmes County is found. This character of the drift is more or less continuous from Hopewell Church west as far as Miley Crossroads in central western Ripley Township. Here, however, the surface of the drift is more undulating and the boundary is hard to draw between the undulating ground moraine and the hummocky, definitely terminal morainic area associated with the lowlands of the preglacial Mohican valley.

In eastern Washington Township in sections 1 and 36 the drift covering the hilltop is slightly undulating, but is known to be not very thick because bedrock shows in a few places. The uplands between Griggs Valley and the valley of Crab Run in sections 10, 11, 14, and 15 of Washington Township are quite thickly covered with till. Very few exposures of the bedrock are to be seen. The till veneer conforms to the surface of the preglacial hills On the more or less flat upland a little undulation is present and the surface is slightly billowy on either side of the state road in sections 14 and 15. The ridge between the valley of Lake Fork and Griggs Valley in sections 16, 17, and 9 in the southern part of Washington Township is thickly covered with till on the northern end, but on the southern end, which is bounded by postglacial Sigafoos Run, the till is very thin and discontinuous. The character of the ground moraine south of the area of terminal moraine near the county line north of Spellacy has been described in connection with the glacial boundary

The high hills in the northwestern corner of Washington Township and across the county line in Green and Lake townships of Ashland County are covered with till which seems to conform with the shape of the preglacial hillsides The thickness and surface expression of the till in the parts of Green and Lake townships, Ashland County, which border on Holmes County, are of the same character as in Washington Township, Holmes County.

Except for the northeastern corner, Knox Township was invaded to only a small extent by the glacier. The drift covering is of the glacial boundary type rather than that of the hills farther to the north which were more heavily overridden by the ice. In the area north of Stones School in the northeastern corner of Knox Township, the drift is quite thick, obscuring the bedrock, and the topography is somewhat suggestive of a sag and swell type. South of the gravel area just south of Nashville, south of Stones School, and south of that portion of Sigafoos Run to the north of the glacial boundary, the till is quite thin and the bedrock is often visible. This region lies on top and to the south of the top of the main divide running across the area. Apparently the ice was just barely able to overtop this ridge. While the till is very thin here, the number of large igneous boulders, many of them 3 to 5 feet in diameter, lying on the surface, is greater than is usual any place else in the region.

The Terminal Moraine.

Areas having a "terminal morainic" topography are shown on the map These areas do not seem to mark any definite ice edge where the ice front halted, making a thicker drift deposit, but rather they seem to be connected with low places of the region, and are mapped to show a definite type of surface. These discontinuous areas of terminal moraine could be connected from valley to valley, and a very respectable series of loops produced. Conrey* found comparable conditions in southern Wayne County to the north:

> ". . . . drift accumulations of a morainic character extend across the southern townships in a discontinuous belt, being well developed in the valleys and of minor importance on the uplands. . . . . If these areas are connected across the intervening uplands they will correspond to the middle and inner or northern belts described by Leverett. The distribution of morainic accumulations in this region near the glacial border apparently has been determined to no small extent by the large preglacial valleys which are at places filled with drift knolls and ridges, while the uplands nearby show comparatively few morainic features. Especially is this true of the east-west valleys, that is, in those at right angles to the direction of the movement of the ice."

The material of the terminal morainic areas is much like that of the ground moraine, the major difference is in the "stronger" surface expression and not in the character of the material. As described under the ground moraine this till is composed of pebbles contained in a silty, clay-like matrix. Occasional areas of gravel deposits are found, but they are usually small and at the upper surface of the till.

Areas such as this, with a knob and kettle topography made up of hap-hazardly placed drift knolls, with depressions between, are usually interpreted as having been caused by the standing or the oscillation of the ice front over a narrow belt at the line of farthest ice advance, or later at some stage of the glacial retreat. The area south of Loudonville may have been formed in this way. The other areas, however, are definitely related to valleys rather than to any standing of the ice edge. The following explanation is offered for the deposition of these masses of unevenly surfaced till. The glacier advanced over the region, but it is supposed that the ice was not very thick, especially at the edge. The thickness of the ice over, and in the valleys would naturally be greater than that on the hilltops. As the ice advanced, considerably more material would be sloughed and scraped off the bottom of the ice in the valleys than on the hilltops. In fact, on the hilltops erosion rather than deposition by the advancing ice may have been the major feature. In the valleys more opportunity for ice blocks to accumulate in the drift would also be afforded. After the glacier had reached its line of greatest advance, it would melt away and down on the hilltops as well as back, so that the hilltops appeared above the surface of the glacier while the valleys were still filled with ice. The drift was already thicker in the valleys, for as the ice was thin on the hilltops, there could be less material contained in the ice here than in that in the valleys. Ice remaining in the valleys would take much longer to melt, would melt unevenly, and this uneven melting would contribute to uneven deposition of drift. Blocks and masses of ice would be carried in the drift slumping down from the sides of the parts of the glacier remaining and these would partially contribute to the formation of depressions in the present topography. By the time these ice masses in the valleys had melted pretty well down, the melt water would be concentrated between the ice and the valley walls, particularly if the ice were in a valley which had an open drainage way to the south. Under such circumstances the material deposited after an open drainage way was established would be more or less assorted and stratified. Such stratified deposits, deposited between masses of ice and the valley walls, are very abundant in the larger open valleys in the form of kames and kame terraces.

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*Conrey, G. W., Wayne County, p. 26, and map in pocket.

These morainic deposits are located in the upper part of the valley of Paint Creek in southern Ripley and northern Monroe townships; in parts of the valley of Crab Run, not taken up with kame deposits; in the large preglacial Mohican valley south and west of Shreve and along the south side of the valley between Big Prairie and Loudonville; and to the southeast of Loudonville in southern sections 6 and 7, and western Section 8, in the western part of Washington Township. This last mentioned area of terminal moraine is the only one which is on the upland. Even here this upland is not as high as the main divide. The deposits in the preglacial valley between Big Prairie and Loudonville may be in part morainic but if so are masked by stratified material.

Deposits in the preglacial Mohican valley south and southwest of Shreve just south of the Wayne-Holmes county line and the extension to the southwest south of Big Prairie, in northwestern Ripley Township are a part of those mapped and described by Conrey farther to the north in Wayne County.* Leverett has also described this area of morainic topography.† The latter merely mentions the deposits, but Conrey gives a good description of them in Wayne County. Neither of these authors, however, distinguished between the morainic knolls between Big Prairie and Centerville which are made up chiefly of till, and the morainic-looking deposits nearer the center of the old valley which are made up mainly of stratified material. In the present paper the two types of deposits will be separated. Just south of the county line between Centerville and Big Prairie the topography is of a sag and swell character rather than of a knob and kettle type. It is not well marked off from the undulating upper slopes and hilltops to the south. The boundary between the ground moraine and the terminal moraine is therefore indefinite at this place and the boundary might be drawn somewhat higher or lower. In this region the terminal moraine exhibits very little in the way of undrained depressions of the real kettle hole type usually associated with a terminal moraine. The territory to the south mapped as ground moraine does not seem, however, to have quite so much of a sag and swell character. Near Centerville the moraine is weakly developed. A bit farther to the west nearer Big Prairie, in Section 28 and northeastern Section 29, the surface is more irregular and hummocky. This is especially evident near Big Prairie where the terminal moraine grades into deposits of kame-like character. A small extension of the moraine south of Odell Lake seems to be plastered against the hillside and up to the top of the ridge, but soon merges into ground moraine to the south.

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*Conrey, G. W., Wayne County: page 27 and map in pocket, 1921.

†Leverett, Frank, Mon. 41, p. 391.

In central Section 31 in northwestern Ripley Township the terminal moraine extends to an altitude of approximately 1,160 feet. All of Section 32 around Sprang School shows well developed knob and kettle topography. Some of these knobs are somewhat gravelly, but the material on the whole is mostly till. These knobs rise from 10 to 30 feet above the general level.

The upper or western portion of the valley of Paint Creek and its tributary valleys are partly filled with drift which is quite thick. The drift is known to be more than 130 feet thick in the valley bottom on the north side of Paint Creek in southeastern Section 15 in central southern Ripley Township, where a well on the farm of E. V. Gorrell is 130 feet deep and does not reach bedrock. The elevation of the well head is 1,020 feet. Mr. Gorrell states that a good flow of water was attained at this depth in a sand layer. Most of the drift here has an undulating surface and in places it approaches a knob and kettle topography. It is somewhat like the morainic surface in northwestern Ripley Township—not especially strongly developed. Prominent knolls of till are present in places, however. The streams tributary to Paint Creek seem to have established their courses from one depression to another. In the head waters the original topography is rather effectually masked. Probably preglacial Paint Creek occupied a good sized valley. Related to this morainic area small patches of gravel are present here and there, mostly near the streams and especially near Paint Creek. These are so small, however, that they were not mapped separately.

On the higher hills the drift is also fairly thick. Bedrock through here outcrops but rarely and not at all at the lower levels. The upland surfaces are flatter than those lower down, but are undulating in many places. The boundary between the ground and the terminal moraines is often not well marked. The ground moraine on the hilltops has a weaker expression than on the surfaces lower down. The boundary is therefore drawn where believed to best represent the change in surface character.

In the vicinity of Knox School in southeastern Washington Township in the valley of Crab Run, a small area has a terminal morainic expression. For about a half-mile on either side of the stream low drift knolls partly fill the valley and are plastered against its sides. The knolls in this area are feebly developed and the area as a whole can by no means be taken as typical of a terminal moraine. It is thought that the knolls are more definite than any undulations on the upland nearby and so the area is mapped as different from ground moraine.*

A small area of drift knolls is present in northern Washington Township between the lower part of Crab Run and Lake Fork. In this small area mainly in Section 35, till knolls are banked against the hillside, and across the low divide to the west. This area is somewhat related to areas of stratified drift nearby, but seems to be made up entirely of till.

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*Conrey, G. W., Wayne Co., pp. 34-36, and map, describes such areas in Wayne County as "minor morainic areas on the ground moraine."

One of the best developed areas of morainic topography is in sections 6 and 7, Washington Township and Section 12 of Hanover Township, Ashland County, just south of Loudonville. It is very close to the glacial boundary, in fact, it is the closest in the region. It differs from those previously described, being on the upland rather than in the valleys or along the valley sides. It attains an elevation of 1,160 feet in Section 12 of Hanover Township and 1,240 feet in northwestern Section 8, Washington Township. The maximum development, however, is not reached on this last higher hilltop. On the north, the area grades into a region of gravel kames and kettles, where the drift is thicker. The material is till, with only a small amount of gravel intermixed near the surface. At the county line and along the gravel road leading from Loudonville to Spellacy just west of the county line, the surface is very hummocky—real knob and kettle topography. Drift knolls 10 to 20 feet or more in height are scattered about and the depressions between are in many cases undrained kettle holes. Several of these kettle holes are partly filled with water, making small ponds and others show that small ponds existed in them until very recently. The largest of these is over 300 yards in diameter, and several have a diameter of more than 150 yards.

Stratified Deposits.

Stratified deposits of several types exist in the area. They are: valley trains, kames and kame terraces, eskers, and lake deposits. Valley trains will be mentioned briefly; eskers will be included in the treatment of kames and kame terraces, which will be treated in some detail because of their importance in this region; and the lake deposits will be located and described.

Valley Trains.

Valley trains, consisting of outwash deposited by melt water concentrated in streams flowing to the south, were deposited in the lower portion of the valley of Shrimplin Creek; in the lower part of Lake Fork valley; in the lower part of Griggs Valley; and in the valley of the Mohican River. This last extends far to the south and on down the Walhonding and Muskingum rivers. Along Shrimplin Creek and along the Mohican River these valley trains have been cut into by later stream erosion, and the outwash material remaining is in terrace remnants along the valley sides. The areas of valley train gravels in the region are shown on the map. The major one, that in the Mohican valley, of which that in the lower Lake Fork valley really is a part, extends far beyond Holmes County and is complicated by association with Illinoian glaciation in part of its course below Brinkhaven. A discussion of its features does not come within the scope of this paper. The one in the lower part of Shrimplin Creek valley more properly belongs with the deposits of Killbuck valley, which will be described elsewhere. That in the lower part of Griggs Valley will be taken up again in the description of the kames and kame terraces in that valley.

Kames and Kame Terraces.

Kames and kame terraces are the most unusual features connected with the glaciation of this region. Kame terraces have been described in the eastern United States,* but their only previous notice in Ohio, as far as the present writer is aware, is a brief mention of "esker terraces" by Wright,† located ". . . . in the River Styx in Medina County, between Seville and Wadsworth, and in the Mohecan River,‡ in Wayne County, in the vicinity of Wooster." As explained previously, it is believed that ice remained in the valleys after it disappeared from the hilltops. In a few cases, after the ice melted below the hilltops, temporary lakes were formed between the remaining ice mass and the hillside, and in these temporary lakes silt and gravel deposits were laid down. Some evidence of these ice-margin lakes is to be found, but apparently the ice-margined lake stage in any of the valleys was not very long lived. Flint§ has described ice-margin lake deposits of Connecticut in great detail. Most of the deposits in the valleys of this area, while bearing some similarity to Flint's ice-margin lake deposits, are not thought to have been deposited so much in lakes as in temporary channels between the ice remaining in the valley and the valley sides. Spillways© such as are associated with the Connecticut ice-margin lake deposits, are not present in this area. The water was flowing to the south throughout the period of deposition of most of this material.

After the ice in the valley melted completely out, a hummocky terrace-like structure was left along one or both of the valley walls, with a depression—really an elongate kettle or series of kettles—in the central portion of the valley through which the present stream flows. The sides of these kame terraces show ice-contact slopes, where the gravel, formerly in contact with the ice mass, had slumped down upon melting of the ice. (See Fig. 3). These slopes have previously been regarded as stream cut, but while some stream cutting has taken place, most of the slopes are regarded by the writer as original ice-contact slopes. A method of testing the ice-contact character of the slopes bordering the streams is to compare them with those bordering the kettle hole lake basins, especially of Odell and Long (Bonnett) lakes. The slopes bordering the lakes must of necessity be original—no stream cutting can have occurred. By comparison therefore it is found that the two

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*Salisbury, R. D., Surface Geology—Report of progress, N. J. Geol. Survey, Ann. Rept., 1892, 93, p. 156, 1893.

Alden, W. C., The Physical Features of Central Massachusetts: Bull. 760, pp. 47–49, 1924.

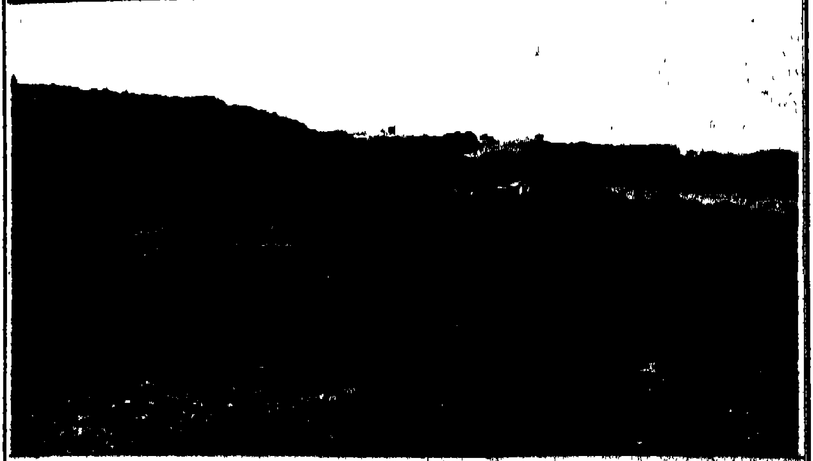
Goldthwait, J. W., Geology of New Hampshire: Handbook No. 1, N. H. Acad. Science, pp. 35–36, 1925.

†Wright, G. F., Postglacial Erosion and Oxidation: Bull. Geol. Soc. America, Vol. 23, p. 285, 1912.

‡Killbuck Creek is probably intended here.

§Flint, R. F., Glacial Geology of Conn.: Conn. State Geol. and Nat. Hist. Survey, Bull. 47, 1930.

©Flint, R. F., Glacial Geol. of Conn., p. 99.



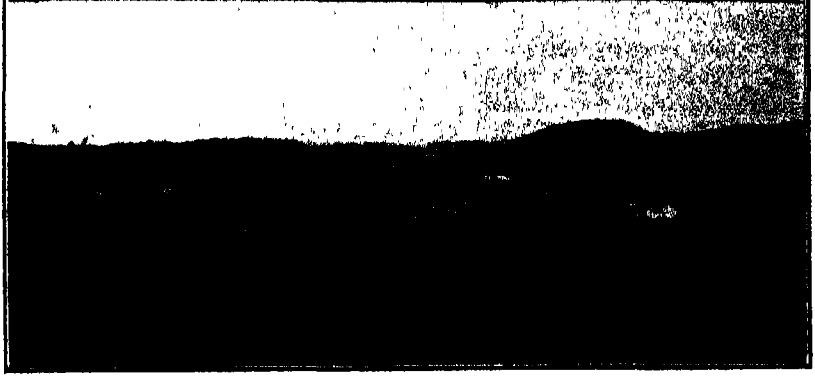


FIG. 3. Typical kame terrace showing ice-contact slopes. Stagnant ice rested in the foreground. West side of Killbuck valley, near Holmesville. (This is in Prairie Township, just east of the area under discussion.)

FIG. 4. Looking northwest across the valley of Lake Fork, southern Section 8, Washington Township. Kame deposits in foreground, till veneered rock-hills in background.

FIG. 5. Valley train in abandoned valley of Sigafoos Run (Griggs Valley). Looking north from glacial boundary, in Section 21, Knox Township. The till-covered hills on either side are remnants of the Harrisburg peneplain.

kinds of slopes are similar, and that the depressions through which the streams flow are merely drained elongate kettles.

Kames and kame terraces will be treated together. A kame in the present paper is a gravel knoll, deposited at or near an ice edge by running water. All gradations, from single isolated kames, to groups, and to terraces made by kames packed closely together, are found.

Valleys which carry these kame and kame terrace deposits are: the abandoned preglacial Mohican valley from Shreve to Loudonville; the valley of Lake Fork, both north and south of the great preglacial valley; the abandoned valley called Griggs Valley, which was formerly occupied by Sigafoos Run in preglacial times; the upper and especially the lower part of the valley of Crab Run; and a small valley northwest of Miley Crossroads in central western Ripley Township.

While these are the only kame and kame terrace deposits to be discussed in the present paper, it might be noted here that similar deposits are found in the deep valleys in the surrounding glaciated territory. Such deposits are particularly well developed in the valleys of Killbuck and Martins creeks in the central northern part of Holmes County.*

Lake Fork Valley—In the southern part of the valley of Lake Fork, that is, in section 8 and 17 of Washington Township, Leverett† observed:

> " . . . . in the midst of the valley, at considerably lower levels, there is a knob-and-basin topography. The basins cover several acres and the centers are depressed 10 to 15 feet or more below their rims. Their bottoms are peaty and marshy, and therefore presumably filled to some depth. They are surrounded by knolls of various sizes, form and trend, while near them at the border of the valley are level-topped gravel deposits standing 50 feet or more above the general level of the morainic tracts in the valley. Phenomena somewhat similar to these are displayed in several valleys in northwestern Pennsylvania just above the glacial boundary, and may be common in other parts of the glaciated district. Their cause is not well understood, but it is thought that they are probably due to the lingering of an ice mass in the central portion of the valley after a passage for the escape of water from beneath the ice had been opened along the borders of the valleys."

These knolls are regarded by the present writer as kames and not as morainic knolls. These kames fill the valley northward to about the place where the Loudonville-Millersburg road crosses the valley in northeastern Section 8. From the state road north to where Lake Fork leaves the preglacial Mohican valley, the kame-like knolls seem to be more confined to the valley sides and a more definite depression is present in the center of the valley through which Lake Fork flows. This depression is believed not to have been cut by the stream but to represent the place where an ice block or blocks rested while deposits were being banked up between the remaining ice and the valley side. These deposits, while rudely terrace-like, do not have a flat top. (See Fig. 4.) The surface is very hummocky, being made up of kames and kettles. The inner borders of these terraces nearest the stream are ragged and represent ice-contact slopes against which the ice rested while the gravel was being deposited between the ice and the valley wall.

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*White, G. W., An Area of Glacier Stagnation in Ohio: Journal of Geology (in press), 1931.

†Leverett, Frank, Mon. 41 U. S. Geol. Survey, p. 391.

These gravel deposits in this part of Lake Fork valley seem to have been deposited by running water and not to have been deposited in lakes held in between the remaining ice and the valley wall. While these structures do not have flat tops such as would be deposited by a stream flowing south, it is believed that the absence of the flat top is because smaller ice blocks were numerous between the valley walls and the main mass of ice in the center of the valley. The gravel would be deposited between these masses of ice and perhaps entirely over them, so that originally this deposit may have had a flat top. When the many buried ice blocks melted, the surface became hummocky and kettled. If many blocks of ice of different sizes were buried in the terrace, it might show no traces of an original horizontal surface after the melting of all the buried blocks.

In northern Section 4 and southern Section 3 the deposit on the west side of the stream against the valley wall is gravel. Most of the deposit on the east side, however, is undulating till deposit which has been mapped as terminal moraine.

Griggs Valley—The abandoned valley of Sigafoos Run, which somewhat parallels the valley of Lake Fork before joining it in Section 4, Washington Township, is locally called "Griggs Valley." Gravelly kames, which are related to the kame gravels of the Lake Fork valley, are found from Griggs Valley School to the north end of the abandoned valley. Some of the gravel is quite coarse, containing cobbles up to one foot in diameter. In northeastern Section 9, in the north end of the valley, the material becomes more and more mixed with till. The deposit is quite terrace-like at the north end of the valley in central eastern and northeastern Section 9.

A considerable amount of melt water from the ice made its way to the south down this abandoned valley to Sigafoos Run which now flows out through the hills at the glacial boundary. A valley train, which is fairly level, heads at some kames about a quarter of a mile south of Griggs Valley School. (This is well illustrated in Figure 5.) It is made up of both sand and gravel, some of the latter being quite coarse. The elevation here is about 1,060 feet and decreases to 1,020 feet at the south end of the valley train. Some of the material of the southern part of this valley train may have been washed down from the vicinity of Nashville through the gorge-like valley of Sigafoos Run which carried melt water from an area to the west of Nashville. When the ice finally withdrew, the old outlet of Sigafoos Run to the north was choked. The new outlet through the hills to the west had carried sufficient melt water to cut the new channel so deep that it was retained.

Abandoned Valley, Sections 3 and 34, Washington Township—This abandoned valley, formerly tributary to the pre-glacial Mohican, is partly filled with kames, with an esker in the central part. The kames are 20 to 30 feet high and not packed tightly together. The evidence of many ice blocks and masses is quite clear in this short stretch. The fact, that ice in this valley was old and rotten and had no forward motion whatever, is shown by the presence in the center of this valley of the largest esker in Holmes County. This esker is a sharp ridge, 50 feet high in places and less than 20 in others, extending almost north and south for about a mile. The top is not level but quite ragged. The material is sand and fine gravel. The esker structure is probably much higher than it now appears because it is partially buried in later kame and wash deposits. Some drainage in addition to the subglacial drainage through the esker tube came down here beside the ice to join Lake Fork and then flow out to the south.

Crab Run Valley—The lower half and the headwaters of the valley of Crab Run have some gravel deposits separated by an area of weak terminal moraine already described. The deposits in the lower part of the valley will be taken up first.

To the south of the village of Lakeville are some of the best developed kame terraces of the whole area. A terrace made up of fine gravel is present for a little over a mile on either side of Crab Run south of Lakeville. The terraces are over a quarter of a mile wide and have a very hummocky surface with ice-contact slopes nearest the stream. Crab Run has done some lateral cutting but in the main the shallow inner valley is the low place or connected kettles left when the ice finally melted out of this valley. In places the terraces are 40 feet above the stream. Near Lakeville they have an elevation of about 980 feet. The tops of the terraces slope to the north, indicating that probably the drainage was north in the valley of Crab Run into Lake Fork and thence south, as is the present day drainage. The absence of gravel deposits in the southern part of the valley around Knox School precludes the possibility of any drainage to the south.

The terrace effect dies out and becomes rather an area of separate kames about a mile from Lakeville. Well developed kames continue from where the definite terrace seems to end up the valley into sections 11 and 12. The kames are higher and better developed near the valley wall, and are lower near the center of the valley. The material seems to be mainly fine sand and gravel. On the eastern side of the valley at the corners of sections 11, 12, 1, and 2 a north-south esker one-quarter mile long parallels the valley.

From the northern part of sections 11 and 12 south to the Loudonville-Nashville road is an area of low till knolls described previously. West and south of Nashville the head of the valley of Crab Run is partly filled by a few low gravelly kames which are also plastered against the hillsides. Above the area of gravelly kames the upper slopes are only slightly undulating and the deposit is till. One mile southwest of Nashville are low kame swells with some 20 to 40 foot kames to the west against the hillside. The material as seen in a small pit is mostly fine gravel. This area of kame and kettle topography is quite subdued and not nearly as pronounced as that in the valleys here-to-fore described. These kame gravels could very well have been deposited off a retreating ice edge rather than around detached blocks, as was the case in many of the other valleys. The melt water from this area drained through a spillway to the southwest which connected the headwaters of Crab Run with the headwaters of Sigafoos Run. This took water from the vicinity of Nashville only and not from as far north as the kame deposits near Lakeville.

Central Western Ripley Township—A small area of gravel deposits is found in central western Ripley Township northwest of Miley Crossroads, practically confined to eastern Section 6. This is in the headwaters of a small stream flowing north to Odell Lake. The material is fine gravel and sand, mostly aggregated in kames and kame swells. The slopes of some of the kame swells are quite ragged, showing good ice-contact characteristics. A small esker 20 feet high and a quarter of a mile long, trending north-northeast is present in the center of the valley. The northern part of this small area of gravel deposits is surrounded by terminal moraine and on the south it is in contact with the upland and its ground moraine.

Preglacial Mohican Valley—The gravel deposits in the preglacial valley, where it crosses north and northwestern Washington Township, constitute the largest area and in some repects the most complex of any in the valleys of the region. Most of these deposits were laid down by running water, but some material was deposited in temporary lakes. Here also the largest continuous ice blocks were left as shown by present basins some of which now contain lakes.

This valley is filled to a considerable depth. At the south end of Odell Lake a well 200 feet deep did not penetrate to the bedrock. At Lovells Corners where the 3 C highway crosses from Holmes County into Ashland County, a well 110 feet deep was in gravel all the way. The valley filling is mainly aggregated in single and massed kames. The material is principally gravel, with some sand intermixed. A few of the knolls seem to contain some till and these may represent almost completely buried terminal morainic knobs. Level expanses are found here and there between some of the kames. This material, which was deposited in short-lived lakes, is more sandy and thinner bedded than that of the kames. In the northwestern corner of Washington Township in sections 29 and 30 is a well-marked flat area of sand and fine gravel, the elevation of which is approximately 1,000 feet. It is probably a wash plain deposited around ice blocks.

From Big Prairie to Lakeville the south side of the valley has gravel kames banked against the valley wall. The central part of the valley is occupied by the depression partially filled by Odell Lake. Just east of Big Prairie is a large elongate kame, trending east and west, made up of fairly coarse gravel. The gravel is 30 to 40 feet thick with apparently sand below. The gravel in the kames from Big Prairie to Lakeville, banked against the hillside, seems to be fine and sandy, with many sand layers. To the southeast the kame area grades into an undulating region of terminal moraine.

North of Lakeville, between that village and the county line, is a considerable area of kames and kettles. The surface is not as level as it appears from an examination of the topographic map. From Lake Fork west to Loudonville is an area of very well developed kames and kettles, some of the kettle holes containing tiny ponds. Other kettle holes, once containing ponds, as shown on the topographic map made in 1912, now are bogs. In general most of the smaller kettle holes are fairly well drained, because they are in gravel and the ground water soon percolates below the level of the bottom of the kettle holes. Most of these are from 10 to 30 feet deep. The larger basins in this region will be described under the heading of "lake basins"

In the vicinity of Loudonville and for a mile to the east, the valley is constricted and the area of kame deposits is narrower than that farther to the east. In northwestern Section 6, Washington Township, near Loudonville the gravel kames are especially well developed and many marked kettle holes, some of them over 100 yards across and 20 to 40 or more feet deep, are present between the kames. The gravel is medium to fine-grained. The bedding dips in different directions at various angles. The area just beyond the Loudonville city limits, crossed by the state road to Millersburg, is one of the most typical kame and kettle areas in the region under discussion

Lake Deposits.

As the ice advanced into the region, the northward flowing valleys were the sites of temporary lakes, and drainage was established over the lowest divides to the south. It was in this way that the lower course of Lake Fork was established. The glacial outlets of all the other lakes were not cut down deeply enough to be permanent streams. As the ice retreated, the valleys, which slope to the north, again became the sites of lakes which emptied to the south through low places in the divides. These lakes were ephemeral, and surprisingly little evidence of their existence remains. The old beds of two of these lakes—flat areas of sand and silt—were observed. One, which covers an area about one mile long and one-half mile wide, is shown on the map in north central Monroe Township, a mile east of Phinney School. Lake deposits of this sort are also found at the low pass between the head waters of Crab Run and Sigafoos Run along the Knox-Washington township line one mile west of Nashville. Below the sandy surface, varved material probably exists, but no exposures are present.

Other lakes of an even more temporary character existed from place to place where water was trapped between the stagnant ice in the valleys and the valley walls. Such areas are not mapped separately because they are in intimate association with the kame gravels with which they are mapped.

Deposits of small temporary lakes are found around the bases of some of the kames in the preglacial Mohican valley. These show that the drainage from one low point to another was at places quite poor after the deposition of drift in this part of the region. On the north side of the 3 C highway in northern Section 32 of Washington

Township poorly exposed, undulating lacustrine layers were measured as follows:

	FT.	IN.
Gravel, very poorly sorted	4	0
Layers of sandy silt and darker silty clay, varying from 1/64 to 1/4 inch in thickness	5	6

A small deposit, the laminations of which may be seasonal, was observed along a lane in north central Section 6 of Washington Township, at an elevation of from 1,020 to 1,040 feet. This deposit is as high, or higher, than most of the kames to the west and north. The clay layers were from 1/8 to 3/4 of an inch thick and the sand layers from 1/64 to 1/4 of an inch thick. Each layer of clay had many thin sandy partings. This deposit is at the edge of an area of kame gravels where apparently a small lake was trapped between the stagnant ice to the north and the valley wall to the east. The material was measured here as:

	FT.	IN.
Gravel	8	0
Clay and sand, (varved?)	7	6

The peat and muck deposits, in some of the small kettle holes and in some of the larger ice block depressions such as those in the northwestern corner of Washington Township, are later than glacial times and do not come within the scope of the present paper. Some have already been described.*

LAKE BASINS AND PRESENT LAKES.

The lake basins in the region are all glacial in origin and are associated with stratified material in the preglacial Mohican valley. They are all kettle holes, some of great size. As the ice melted many large depressions were left in the stratified material in the valleys. The borders of these depressions show excellent ice-contact slopes where the gravel was built up against the ice blocks. Here there is no question about the slopes being trimmed by lateral planation of streams, because these depressions are occupied by lakes. By analogy, therefore, between the slopes of the lake basins and the slopes of the depressions now occupied by streams, the conclusion has been drawn as to the original ice-contact character of the slopes described previously. Those that were drained became part of a stream channel. Those which were not drained remained as lakes, some of which have been gradually filled, forming marshes.

The largest is Odell Lake, between Big Prairie and Loudonville. It is about one mile long and about one-quarter of a mile wide. It occupies a depression considerably longer but the same width as the lake. The lake is reported to be 15 feet or less in depth throughout. The Odell Lake depression was at one time occupied by a block of ice, which extended from Big Prairie almost to Lakeville.

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*Dachnowski, Alfred, Peat Deposits of Ohio: Geol. Survey of Ohio, Fourth Ser., Bull. 16, pp. 32-33, 77-78, 1912.

Long (Bonnett) Lake is in the northern part of Section 26, extending slightly over the county line into Ashland County. It is about three-eighths of a mile long and a little less than a quarter of a mile wide. The basin which it occupies is about twice the length of the lake. This lake is considerably deeper than Odell Lake, having a uniform depth of 22 to 23 feet. The slopes of this basin show well developed ice-contact features.

Two large depressions and a smaller one, now connected by narrow channels and the whole drained by Plum Run, are found in the northwestern corner of Washington Township as shown on the map. The bottoms of these are at an elevation slightly deeper than 980 feet. The basins, partly filled with silt and organic material, have been artificially drained, and except for a few small patches lower than the usual level, are farmed. The compound basin of this old swamp is made up of smaller coalescing kettle holes rather than being one simple depression. The boundary slope is quite ragged, rising 20 to 30 feet above the former bog. An interesting feature is the presence, well out from the margins of the depression, of several small kames 20 to 30 feet high.

A LIST OF PARASITIC COPEPODS AND THEIR FISH HOSTS FROM LAKE ERIE.

WILBUR M. TIDD,
Ohio State University.

A collection was made of the parasitic copepods of Lake Erie and some of its tributary waters by the writer while assisting on the Cooperative Biological Survey of Lake Erie during the years of 1927, 1928, and 1929. The collecting has been continued throughout the present summer of 1931 at the Franz Theodore Stone Laboratory. In all, some fifteen hundred fish of thirty-eight species have been procured for examination and thirteen species of parasitic copepods found, eight of which are new to the waters of Lake Erie. The following list of thirteen species is a preliminary report on the above collection. The records are for Lake Erie proper unless otherwise noted.

Family ARGULIDÆ.

Argulus appendiculosus Wilson. Host—Found upon a bullhead (probably *Ameiurus nebulosus*). Specimen taken by Professor Stephen R. Williams. New to Lake Erie.

Argulus stizostethii Kellicott. Host—The six specimens captured were all taken while swimming in the plankton. This species was described by Kellicott from specimens on the blue pike "Stizosthethium salmoneum" (probably *Stizostedion glaucum* Hubbs) taken from the Niagara River at Buffalo, New York.

Family ERGASILIDÆ.

Ergasilus centrarchidarum Wright. Hosts—The rock bass (*Ambloplites rupestris*), and the large-mouth bass (*Aplites salmoides*). New to Lake Erie.

Ergasilus caeruleus Wilson. Hosts—The sauger or sand pike (*Stizostedion canadense canadense*), the blue pike (*Stizostedion glaucum*), the gray pike (*Stizostedion vitreum*), the yellow perch (*Perca flavescens*), the blue gill (*Helioperca incisor*), and the trout perch (*Percopsis omiscomaycus*). New to Lake Erie.

Ergasilus versicolor Wilson. Host—The channel catfish (*Ictalurus punctatus*). New to Lake Erie.

Ergasilus cotti Kellicott. Host—The rainbow darter (*Poecilichthys coeruleus*) from Lake Erie drainage. This is the first time *Ergasilus cotti* has been reported since it was described in 1892 by David S. Kellicott from specimens found on the sculpin, "Cottus ictalops" (*Cottus bairdii bairdii* Girard) captured near Westerville, Ohio.

Family LERNAEOPODIDÆ.

Achtheres ambloplitis Kellicott. Host—The rock bass (*Ambloplites rupestris*).

Achtheres micropteri Wright. Host—The large-mouth bass (*Aplites salmoides*). New to Lake Erie.

Achtheres pimelodi Kröyer. Hosts—The channel catfish (*Ictalurus punctatus*), and the yellow bullhead (*Ameiurus natalis*) from Sandusky Bay.

Achtheres coregoni (S. I. Smith). Host—The whitefish (*Coregonus clupeaformis*).

Salmincola inermis (Wilson). Host—The lake herring or cisco (*Leucichthys artedi*). New to Lake Erie.

Family LERNAEIDÆ.

Lernaea cruciata (Le Sueur). Host—The rock bass (*Ambloplites rupestris*).

Lernaea tortua (Kellicott). Host—Straw-colored minnow (*Notropis deliciosus stramineus*). New to Lake Erie.

NEW AND INTERESTING PLANKTON ALGÆ FROM LAKE ERIE.

LEWIS H. TIFFANY,
Ohio State University,
AND
ELBERT H. AHLSTROM,
Northwestern University.

For the last five summers a rather intensive study has been made of the plankton algæ* of Lake Erie along the Ohio shore and in the region of Gilbraltar Island, upon which is located the Franz Theodore Stone Laboratory of Ohio State University. During the past summer particular emphasis has been given to the plankton algæ of Put-in-Bay Harbor of South Bass Island and of ponds on Middle Bass and North Bass Islands.

The three Bass Islands lie near the Ohio shore in Lake Erie, some few miles north of Catawba Peninsula. Gibraltar Island lies in Put-in-Bay Harbor off the north shore of South Bass Island, thus giving considerable protection to the harbor from wind and wave action. In the harbor are located three separate bays having "semi-pond" characteristics and known as Squaw Harbor, Terwilliger Pond, and Hatchery Bay.

Some of the following species and varieties collected in this region are apparently undescribed to date. Others because of their varied characteristics or rare occurrence in North America deserve special mention.

Chroococcus limneticus Lemmermann.

(Pl. I, Figs. 2–10)

Bot. Centralb. 76: 153, 1898; Kryptogamenfl. d. Mark Brandenburg 3: 57, Fig. 8, 1907; G. M. Smith, Phytopl. In Lakes Wis. Pt. I: 29, Pl. 1, Fig. 4, 1920. *Chroococcus limneticus* Lemm. var. *distans* G. M. Smith, Bull. Torr. Bot. Cl. 43: 481, Pl. 26, Fig. 26, 1916; *Chr. limneticus* Lemm. var. *carneus* (Chod.) Lemm. Arkiv f. Bot. 2 (2): 101, 1904; Smith, Phyopl. In L. Wis. Pt. I: 30, Pl. 1, Fig. 6, 1920.

Chroococcus limneticus has been observed as a common plankton alga of Lake Erie for a number of years and was particularly abundant this past summer. It is quite variable in size, color, and arrangement of cells within the colony. The diameter of the cells varies from 3.5 to 26μ. The color may be light bluegreen, pale bluegreen, olive green, gray, grayish purple, or even brown. In some colonies the cells are very close together; in others cellular arrangement can be found that is typical of the various recognized varieties of the species. In fact, it is possible to find a complete intermediate series between the species proper and its so-called varieties. In spite of this marked intergrading, it seems desirable to recognize var. *purpureus* (Snow) nov. comb. and var. *subsalsus* Lemm. (see below). In the measurements of a great number of individuals of these algæ three definite means of sizes are noted, corresponding to the species itself and the two above-named varieties. The usual cell size of the species is 6.5 to 9μ.

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*A more comprehensive report of the plankton algae of the Put-in-Bay region of Lake Erie is in an advanced state of preparation.

Var. *distans* G. M. Smith and var. *carneus* (Chodat) Lemm. are merely growth variations of the species. In fact, every gradation in size, shape, color, and arrangement of cells was observed in the Lake Erie material between the species and these two varieties.

Var. **purpureus** (Snow) nov. comb.

(Pl. I, Figs. 11–15.)

Chroococcus purpureus Snow, Bull. U. S. Fish Comm. 22: 383, Pl. 4, Fig. 18, (1902) 1903; *Chr. limneticus* var. *elegans* G. M. Smith, Trans. Wis. Acad. Sci. Arts & Let. 19: 619, 1918; Phytopl. In. Lakes Wis. Pt. I: 30, Pl. 1, Fig. 8, 1920.

Colonies circular to semicircular in front view, somewhat flattened in side view, inclosed by a spherical or oval, hyaline, homogeneous envelop. Individual sheaths of cells may or may not be conspicuous. Cell contents homogeneous. Color blue-green to grayish-purple, or even brown—grayish purple being the usual color.

Diameter cells (without sheath) 13–26μ, usual diameter 16–19μ.

This large variety of *Chroococcus limneticus* is undoubtedly the form Snow described from the Lake Erie region under the name of *Chr. purpureus*. It is often grayish-purple in color, markedly more so than is usual for the species proper. The color is, however, variable. The specimens from East Harbor are predominantly grayish-purple, while those of the Put-in-Bay region are bluegreen or grayish-green. This variety is also identical with var. *elegans* G. M. Smith. Though the latter name is more appropriate, Snow's *purpureus* has priority. It differs from the species proper in its larger size. Due to marked changes in color at different seasons of the year in members of the Chroococcaceæ, names based on color characteristics are not particularly significant.

Var. **subsalsus** Lemmermann.

(Pl. I, Fig. 1.)

Forschungsbr. a. d. Biol. Stat. Zu Plon 8: 84, 1901; Arkiv f. Botanik 2 (2): 101, Pl. 1, Fig. 9, 1904; G. M. Smith, Phytopl. In. Lakes. Wis. Pt. 1: 29, Pl. 1, Fig. 5, 1920.

Diameter cells (without sheath) 3.5–4.5μ.

This variety establishes a range below the usual size of the species as does var. *purpureus* above the usual size.

Merismopedia convoluta Brebisson.

(Pl. II, Fig. 19.)

Kuetzing Spec. Algar. 472, 1849; Hansgirg, Prodromus der Algenfl. v. Bohmen, Pt. 3: 142, Fig. 52, 1893.

Diameter cells, 3.5μ; length of cells, 4.5μ.

The most common Merismopedia in the lake seems referable to this species. The colonies are usually large, seldom having less than 64 cells and frequently numbering thousands. The cells are definitely longer than wide. The colony is flat when the number of cells is small, but when composed of a large number of cells it has a tendency to roll under or overlap itself. The cell color is pale bluegreen, much lighter in the center than around the edges.

Var. **minor** (Wille) nov. comb.

(Pl. II, Fig. 20.)

Merismopedia convoluta Brèb. f. *minor* Wille *in* Geitler, Cyanophyceae *in* Pascher, Süsswasserflora, Deutsch. Öster. u. d. Schweiz 12: 106, 1925.

Diameter cells, 2.75μ; length, 3.5μ.

This variety is definitely smaller than the species proper. In addition the cells are more closely packed together. All colonies observed were large—several hundred to over a thousand cells. Its abundance and regular occurrence with the species seem to warrant varietal rank.

Gomphosphaeria lacustris Chodat.

(Pl. II, Fig. 22.)

Bull. Herb. Boiss 6: 180, Figs. 1A-1G, 1898; *Coelosphaerium roseum* Snow, Bull. U. S. Fish Comm. 22: 387, Pl. 55, Fig. 17, (1902) 1903; *Gomphosphaeria rosea* (Snow) Lemm. Kryptogamenfl. d. Mark Brandenburg 3: 80, 1907.

This alga is a very common, often abundant, form in the lake. The color, though usually pale bluegreen, may be rose or brown. It is undoubtedly the alga that Snow described under the name of *Coelosphaerium roseum* and which later Lemmermann assigned to the genus Gomphosphaeria. Many specimens were found that suited the description as given by Snow in every detail. She realized the resemblance to *Gomphosphaeria lacustris*, but she placed too much emphasis upon the color of the alga under her observation.

Marssoniella elegans Lemmermann.

(Pl. II, Fig. 21.)

Ber d. deutsch. bot. Ges. 1900: 275; Kryptog. d. Mark Brand. 3. 93, Fig. 9, 1910; Geitler, Cyanophyceae *in* Pascher, Süsswasserflora Deutsch., Öster u. d. Schweiz 12: 120, Fig. 155, 1925 ? *Coelosphaerium radiatum* G. M. Smith, Roosevelt Wild Life Bull. 2 (2): 136, Pl. 3, Figs. 9-10, 1924.

Diameter cells, (1–) 2–3μ; length cells, 5–6μ.

This alga appears rarely in the lake proper. It agrees with *Coelosphaerium radiatum* Smith, which Geitler refers to *Marssoniella elegans*, except in the absence of any observable sheath. The Lake Erie specimens usually have 32 to 64 cells in a colony (never less than 16) and have two to four axes of radiation.

The genus Marssoniella must be placed with the Chroococcaceae. There is no justification for its assignment to the Chamaesiphonaceæ by Lemmermann. The relationship to Coelosphaerium is evident, but it seems best to regard it as distinct.

Dictyosphaerium planctonicum nov. sp.

(Pl. II, Fig. 17.)

Colonies usually ovoid and relatively small, containing less than 40 cells. Cells bluntly rounded, ovoid, or markedly ellipsoid. Chloroplasts one or two, parietal, laminate, each with a single pyrenoid. Two (sometimes four) cells often contained in separate envelopes within the colony. Sheath of colony (?) absent.

Cells 8–9μ broad, 12–16μ long.

This species differs from *D. ehrenbergianum* Naegeli (Gatt. einz. Algen 73, Pl. II, Figs. Ea–E1, 1849) in the larger size, in the apparent absence of a sheath around the colony, and in the curious arrangement of cells in multiples of two, which often have a separate envelope surrounding them. Were it not that some colonies lack this latter feature, the assignment of this species to the genus Dictyosphaerium is open to question. Abundant in Put-in-Bay Harbor.

Oocystis eremosphaeria G. M. Smith.

(Pl. II, Fig. 18.)

Trans. Wis. Acad. Sci. Arts & Let. 19: 630, Pl. 14, Figs. 8-9, 1918.

Cells ovoid, up to twice as long as broad. Solitary or in families of two or four. Chloroplasts numerous (40-60), parietal, lenticular, each with a single pyrenoid. Cell wall thick, with a conspicuous polar nodule.

Cells 17-31μ broad, 21-45μ long.

This species is present in the plankton of Lake Erie, though apparently never very common. It is frequently smaller than the dimensions given by Smith, and the original description has been modified accordingly.

Treubaria varia nov. sp.

(Pl. II, Fig. 16)

Treubaria triappendiculata G. M. Smith (non Bernard), Trans Amer. Micros. Soc. 45 (3): 177, Pl 9, Figs 19-23, 1926.

Cells three- or more angled (up to eight-), usually four-, pyramidulate to quadrate in shape (usually pyramidulate), sides of cells concave or straight. Angles broadly rounded, each bearing a single hyaline spine that gradually tapers to near the end, where it terminates abruptly in a sharp point. Chloroplast massive, completely or nearly filling the cell, with one or four pyrenoids (usually four).

Diameter cells (with spines), 48-89μ, (without spines), 8-19μ; spines (20-) 25-38μ long, 3-6μ broad at base.

This species appears to be quite distinct from *T. triappendiculata* Bernard.* The latter according to Bernard's description has three spines usually 15-20μ long, seldom up to 30μ. The spines, moveover, are distinctly punctate. The chromatophore is supposedly flat with a single pyrenoid. *T. varia*, on the other hand, seldom has less than four spines. A few specimens with a single pyrenoid, which show them to be young plants, have spines only 20μ long. An interesting note here is that the spines during June-July averaged about 30μ long, while during August the average length was about 25μ, indicating a definite seasonal variation. The spines are somewhat variable in shape. The usual type seems intermediate between those of *T. triappendiculata* and *T. crassispina* Smith (*loc. cit.*, p. 178, Pl. 10, Figs. 2-5). A few taper to an acute point, while others have subparallel sides that taper abruptly to a sharp point.

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*Dept. de l'Agr. Indes Neerland. 1908: 170, figs. 544-548.

The cell itself ranges in size from 8–19μ, the usual size being about 13μ. These dimensions are larger than those recorded by Smith and much larger than those of the original *T. triappendiculata.* Smith notes the absence of cavities between the base of the spines and the cell wall. The presence or absence of cavities is a variable feature, many cells having distinct cavities, while others lack them. The chromatophore in mature cells always has four pyrenoids, and not single, as Bernard noted for *T. triappendiculata.* It seems desirable, on the basis of the above data, to establish a new species for the American specimens as being distinct from the original *T. triappendiculata.*

This species is very close to *Borgea planctonica* G. M. Smith (Ark. f. Botanik 17: 2, 1922). It differs in having the cells pyramidulate to quadrate in shape, while the latter species has spherical cells. Perhaps the differences are too slight to warrant generic separation.

Micractinium pusillum Fresenius var. **longisetum** nov. var.

(Pl. III, Fig. 34.)

Colonies of four to eight cells. Cells spherical, with 5–8 delicately tapering very long setae on the faces not adjacent to other cells. Chloroplasts single, parietal, cup-shaped, with one pyrenoid.

Diameter cells (without setae), 6–8μ; setae up to 65μ long.

This variety with unusually long setæ was collected at the mouth of the Maumee River.

Micractinium eriense nov. sp.

(Pl. III, Figs. 32 and 33.)

Colonies of 2, 4, or 8 cells (usually 4 or 8, the latter more common). Cells spherical with 8–13 delicately tapering setae on the faces not adjacent to the other cells. Cells usually in a pyramidulate arrangement. Chloroplast single, parietal, cup-shaped, with a pyrenoid.

Diameter cells (without setae), 7–10μ; length of setae, 20–35μ.

This species differs from *M. pusillum* in its larger size and more numerous setæ. The usual number of setæ for each cell is 11 or 12, and the colonies do not contain more than 8 cells. Colonies of *M. pusillum* are normally larger than 8 cells, although colonies of var. *elegans* G. M. Smith (Trans. Wis. Acad. S. A. & L. 19:631, Pl. XII, Fig. 4, 1918) are quite similar to those of *M. eriense.* Collected from Wehrle Pond and

Haunck Pond on Middle Bass Island and from Smith Pond on North Bass during August.

Golenkinia radiata Chodat var. **brevispina** nov. var.

(Pl. III, Fig. 31.)

Cells spherical, solitary, containing numerous, delicate, short setae. Chloroplast single, cup-shaped, with a pyrenoid.

Diameter cells (without setae), 8–19μ; length setae, 8–15μ.

This variety differs from *G. radiata* Chodat (Jour. de Bot. 8:305, Pl. III, Figs. 1–24, 1894) in the much shorter setæ. It differs from *G. paucispina* W. & G. S. West (Trans. Roy. Acad. 32 (Sec. B):68, Pl. I, Fig. 18, 1902) into whose cell size range it runs, in the more numerous, light, and more delicate setæ, and in the cup-shaped chloroplast. Found in Haunck Pond on Middle Bass Island throughout the summer.

Golenkinia maxima nov. sp.

(Pl. III, Fig 30)

Cells spherical, solitary, with fairly long, delicately tapering setae, which are often bent after a short distance from the cell. Chloroplast single, apparently filling the cell, with a large pyrenoid.

Diameter cells (13–) 17–22μ; length setae, 35–45μ.

The setæ of this species are markedly heavier than those of *G. radiata*, and much darker, though comparable in length. The cell diameter is larger than that of *G. radiata*. *G. maxima* is near *G. paucispina* in size of cell, but differs in the much longer setæ. Found in Terwilliger Pond and Squaw Harbor throughout the summer.

Lagerheimia citriformis (Snow) Smith.

(Pl. III, Figs. 27 and 28.)

Phytopl. In. Lakes Wis. Pt. I: 130, Pl. 30, Figs. 1-2, 1920.

Diameter cells (without setae), 8–20μ; length cells, 13–26μ; length setae, 25–60μ.

More variable in Lake Erie than the original description would indicate. Although the chloroplast is usually single, individuals with two parietal chloroplasts are not uncommon. The length of the setæ varies greatly. Specimens from the mouth of the Maumee River have setæ up to 60μ long.

Lagerheimia citriformis var. **paucispina** nov. nom.

(Pl. III, Fig. 26.)

Chodatella subsala var. *citriformis* Woloszynska, Hedwigia 55: 201, Pl. 7, Figs. 15–19, 1914.

Cells ovoid to ellipsoid with a small obtuse projection at each pole. Poles with 2–3 (4) long, hyaline, delicately tapering setae at the base of the polar projections. Chloroplast single, parietal, with one pyrenoid.

Diameter cells, 8–9μ; length, 10–14μ.

Because of its very pronouncedly citriform shape, this alga should be regarded a variety of *L. citriformis* (Snow) Smith and not of *L. subsalsa* Lemm. (Forschungsbr. a. d. Biol. Stat. Plön 6: 193, Pl. 5, Figs. 2–6, 1898). It resembles the latter only in its small size, and differs from the former in its smaller dimensions and its fewer setæ.

Lagerheimia longiseta (Lemm.) Printz var. **major** G. M. Smith.

(Pl. III, Fig. 25.)

Phytopl. inland Lakes Wis. Pt. I: 130, Pl. 30, Figs. 10–12, 1920. *Chodatella longispina* Walton, Ohio Biol. Survey Bull. 24: 64, Fig. 37, (1930), 1931.

Diameter cells, 12–25μ; length, 15–37μ; length setae, 40–60μ.

This alga is quite common in the plankton of the lake region. Its size range is greater than that given by Smith. *Chodatella longispina* is apparently only a large form of this variety. It would appear from Walton's discussion of his species that he is not entirely familiar with the literature on this group of algæ, particularly the thorough American work of G. M. Smith.

Lagerheimia wratislawiensis Schröder.

(Pl. III, Fig. 29.)

Ber. d. bot. Ges. 15: 373, Pl. 17, Fig. 7, 1897; Smith, Trans. Amer. Micros. Soc. 45 (3): 180, Pl. 12, Figs. 10–14, 1926.

Diameter cells (without spines), 3–7μ; length cells (without spines), 10–14μ; length of spines, 14–26μ.

Collected from Haunck Pond, Middle Bass Island. Previously reported for this country only from Iowa.

Franceia tuberculata G. M. Smith.

(Pl. III, Fig. 37.)

Trans. Amer. Micros. Soc. 45 (3): 182, Pl. 12, Figs. 27–30, 1926.

Diameter cells (without setae), 5–12μ; length cells (without setae), 8.5–21μ; length of setae, 7–32μ.

This alga is quite common in the ponds of Bass Islands, though it is seldom found in the lake proper. Colonies consist of 2-4-6-8 (usually 4) closely appressed and parallel cells. No evidence of a gelatinous sheath. Tubercles always distinct, being at times raised as much as 3μ above the cells.

Franceia tuberculata var. **irregularis** nov. var.

(Pl. III, Figs. 35 and 36.)

Cells large, joined in colonies of 4 to 6 or 8 cells; half of the cells in the colony usually arranged at right angles to the other cells, though the arrangement may become somewhat irregular. Cells broadly ovoid with rounded poles; cells where not in contact with other cells clothed with rather long delicate, non-tapering setae with a distinct tubercle at the base of each.

Dimensions as in the species (above).

The variety is characterized by the irregular arrangement of the cells in the colony, instead of having the long axes of the cell always parallel.

Selenastrum bibraianum Reinsch var. **gracile** (Reinsch) nov. comb.

(Pl. II, Fig. 23.)

Selenastrum gracile Reinsch, D. Algenfl. d. Mitt. Th. v. Franken, 1867: 65, Pl. 4, Figs. 3 a–b, 1867.

This alga should not be given more than varietal rank, if it is to be recognized at all. It may be merely a growth form of *S. bibraianum* (Pl. 2, Fig. 24). The two algæ were always found growing together, and occasional colonies had cells typical of both. Autospores have frequently been observed in *S. bibraianum* but never in var. *gracile*. Young colonies of typical *S. bibraianum* are apparently identical with the variety.

Crucigenia apiculata (Lemmermann) Schmidle var. **eriensis** nov. var.

(Pl. III, Fig. 41.)

Coenobe four-celled with a relatively large open space in the center; coenobia frequently multiple. Cells quadrately arranged with base and median part of inner sides in mutual contact, but with the apices and outer faces free. Cells elongate, somewhat lunate, with free ends truncate, and provided on the inner apex with a short conical projection; usually a second projection at the side of the base away from the center of the coenobe. Cells with one to four parietal, disciform chloroplasts, with one pyrenoid.

Diameter cells, 3–5μ; length cells, 6–10μ.

The free apices of this variety have a superficial resemblance to *Crucigenia truncata* G. M. Smith (Phytopl. In. Lakes Wis.

Pt. I: 146, Pl. XXXVI, Figs. 7–9, 1920). On close examination, however, the definite conical projection on the inner side of the apex of the cell shows it to be closer to *C. apiculata* (Lemm.) Schmidle (Allg. Bot. Zeitschr. 6: 234, 1900; Smith, *loc. cit.* Pl. XXXVII, Fig. 1). The variety is found along with the species in Lake Erie. During the past summer it was the dominant Crucigenia in Buckeye Lake, near Columbus, Ohio.

Tetrastrum heterocanthum (Nordstedt) Chodat.

(Pl. III, Figs. 38–40.)

Bull. Herb. Boiss 3: 113, 1895; Smith, Trans. Amer. Mic. Soc. 45 (3): 187, Pl. 15, Figs. 16–20, 1926.

This alga occurs quite generally throughout the region. It is particularly common at the mouth of the Maumee River and in a small pond on North Bass Island. The spines are variable. Many are as delicate as those noted by Smith in Iowa, while others are as pronounced as Nordstedt's original illustration.

Scenedesmus bijuga (Turpin) Lagerheim var. **major** nov. var.

(Pl. III, Figs. 42 and 43.)

Colonies curved with 2–8 cells arranged in an irregularly alternating row. Cells ovoid, with smooth walls.

Diameter cells, up to 13μ; length cells, up to 21μ.

The cells of this variety vary greatly in their arrangement. The colonies are always curved. The alga resembles var. *irregularis* (Wille) G. M. Smith (Trans. Wis. Acad. Sci. Arts & Lett. 18 (2): 448, Pl. XXVIII, Figs. 59–62, 1916), but differs in its much larger size.

New Plankton Algæ from Lake Erie
Tiffany and Ahlstrom

PLATE I.

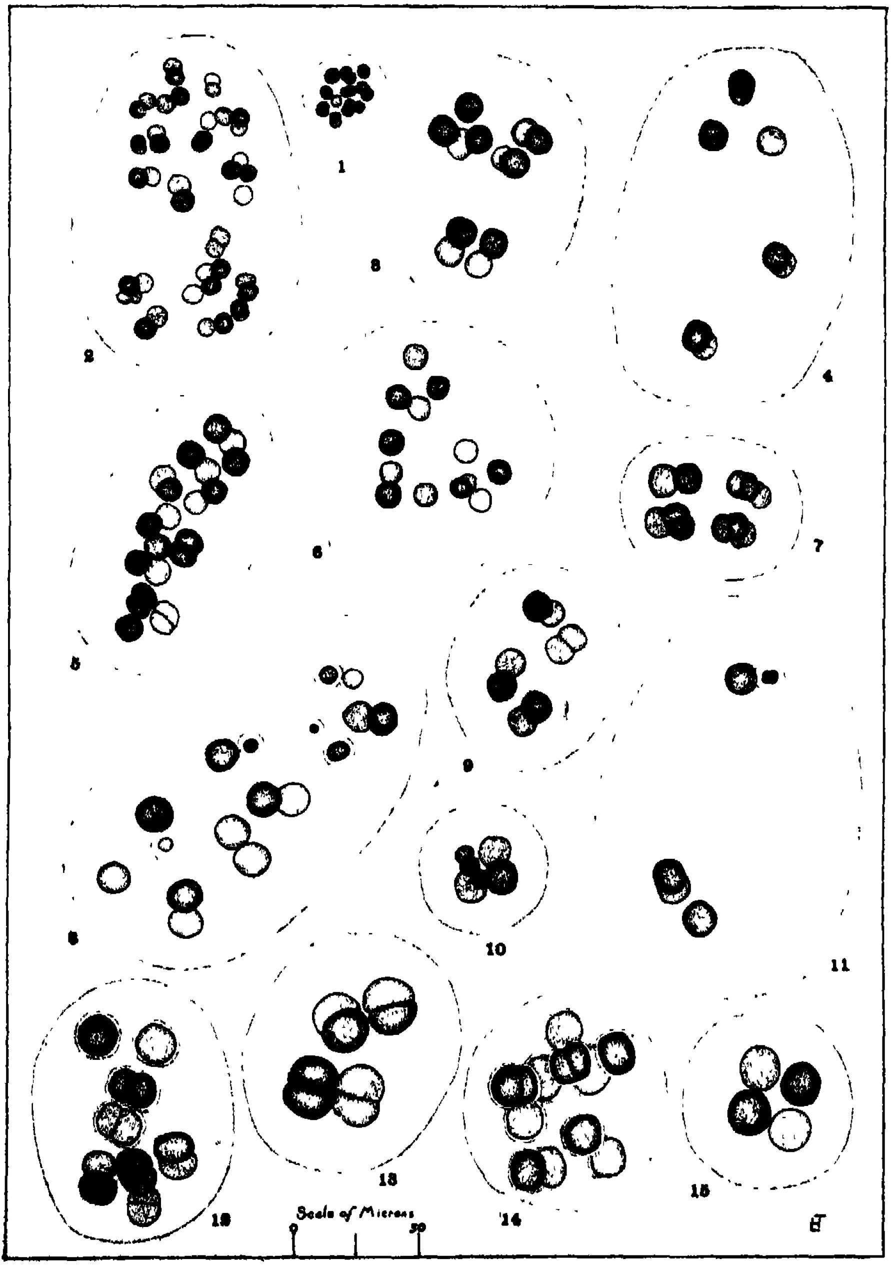

Fig. 1. *Chroococcus limneticus* Lemm. var. *subsalsus* Lemm.
Figs. 2–10. *Chroococcus limneticus* Lemm.
Figs. 11–15. *Chroococcus limneticus* Lemm. var. *purpureus* (Snow) nov. comb. Fig. 11 (= *Chroococcus purpureus* Snow) redrawn from Snow. Fig. 14 (= *Chroococcus limneticus* Lemm. var. *elegans* G. M. Smith) redrawn from G. M. Smith.

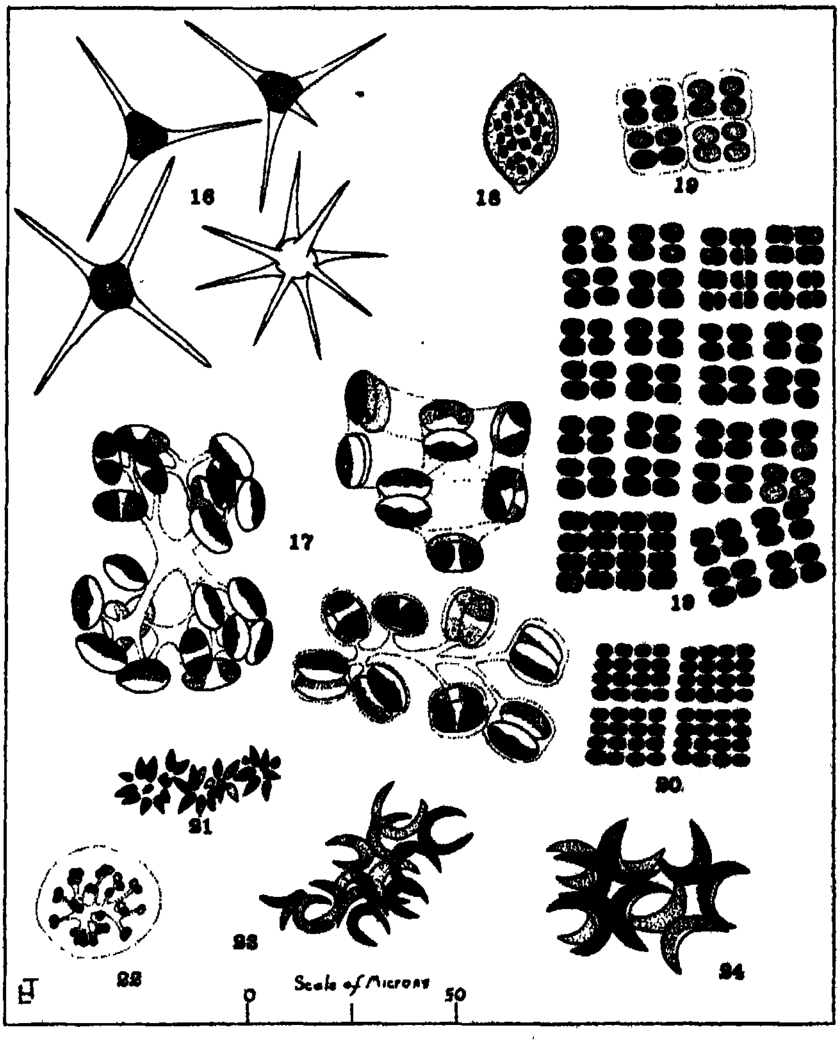

Fig. 16. *Treubaria varia* nov. sp.
Fig. 17. *Dictyosphaerium planctonicum* nov. sp.
Fig. 18. *Oocystis eremosphaeria* G. M. Smith.
Fig. 19. *Merismopedia convoluta* Brebisson.
Fig. 20. *Merismopedia convoluta* Breb. var. *minor* (Wille) nov. comb.
Fig. 21. *Marssoniella elegans* Lemm.
Fig. 22. *Gomphosphaeria lacustris* Chodat. (Redrawn from G. M. Smith.)
Fig. 23. *Selenastrum bibraianum* Reinsch var. *gracile* (Reinsch) nov. comb.
Fig. 24. *Selenastrum bibraianum* Reinsch. (Redrawn from G. M. Smith.)

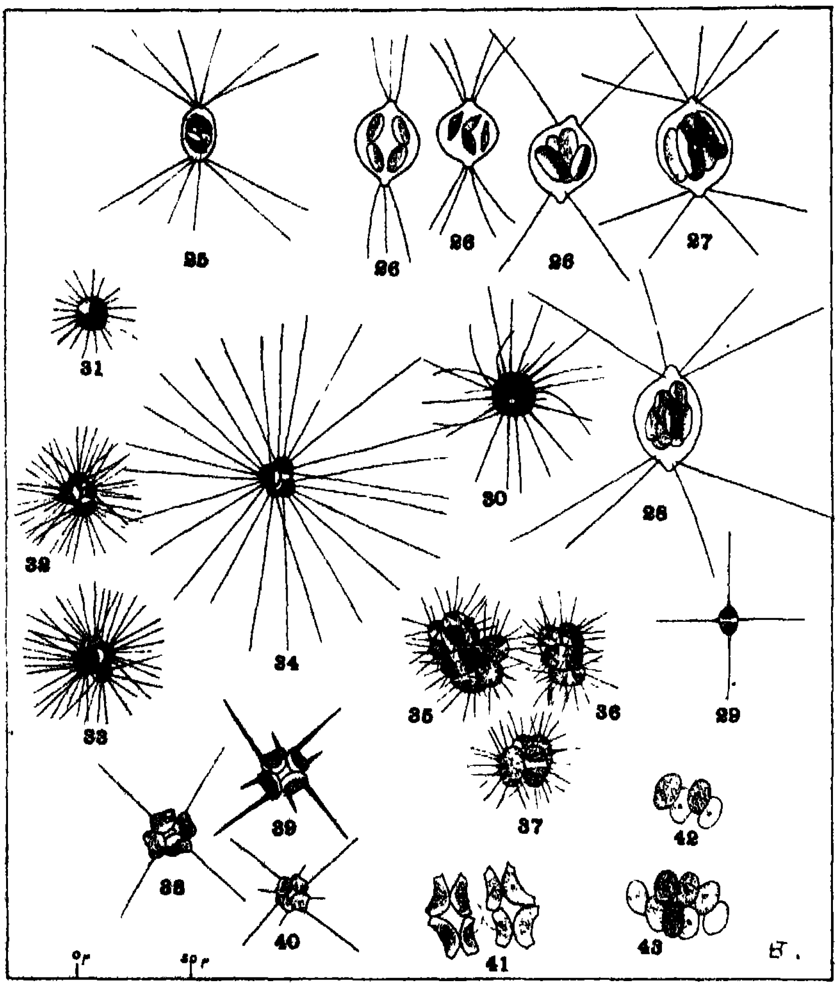

Fig. 25. *Lagerheimia longiseta* (Lemm.) Printz var. *major* G. M. Smith.
Fig. 26. *Lagerheimia citriformis* (Snow) Smith var. *paucispina* nov. nom. (Middle Figure redrawn from Woloszynska.)
Figs. 27 and 28. *Lagerheimia citriformis* (Snow) G. M. Smith.
Fig. 29. *Lagerheimia wratislawiensis* Schroder.
Fig. 30. *Golenkinia maxima* nov. sp.
Fig. 31. *Golenkinia radiata* Chodat var. *brevispina* nov. var.
Figs. 32 and 33. *Micractinium eriense* nov. sp.
Fig. 34. *Micractinium pusillum* Fres. var. *longisetum* nov. var.
Figs. 35 and 36. *Franceia tuberculata* G. M. Smith var. *irregularis* nov. var.
Fig. 37. *Franceia tuberculata* G. M. Smith, showing large tubercles.
Figs. 38–40. *Tetrastrum heterocanthum* (Nordst.) Chodat.
Fig. 41. *Crucigenia apiculata* (Lemm.) Schmidle var. *eriensis* nov. var.
Figs. 42 and 43. *Scenedesmus bijuga* (Turp.) Lager. var. *major* nov. var.

NOTROPIS VOLUCELLUS WICKLIFFI, A NEW SUBSPECIES OF CYPRINID FISH FROM THE OHIO AND UPPER MISSISSIPPI RIVERS.

MILTON B. TRAUTMAN.

A study of the material now preserved in the Museum of Zoology, University of Michigan, and the Ohio State Museum, makes it apparent that several more or less well defined subspecies of the shiner *Notropis volucellus* (Cope) occur in various parts of its range.

In the present paper three northern forms of this species are differentiated and their ranges and habits discussed and defined. It is hoped that the southern forms will be dealt with later. This paper is an extension of the contributions to the status of *Notropis volucellus* and its subspecies which have been made by Hubbs and Green (1928: 375–379) and Hubbs and Ortenburger (1929: 67–70).

The range, variation and habitat of the three forms are as follows:

1. *Notropis volucellus volucellus* (Cope) ranges throughout the Great Lakes drainage, from Lake Champlain to Minnesota, northward to Lake Nipigon in Ontario, and southward to a distance as yet undefined. Specimens apparently referable to *volucellus* proper come from as far south as various parts of the Cumberland and Tennessee rivers systems. Farther south it appears to be represented in the upland streams by at least two different subspecies. The most extreme of these forms, from northeastern Mexico, is being described by Hubbs and Gordon. The southwestern upland form of the United States has been regarded as referable to *N. v. volucellus*, but new material indicates that one or more subspecies may in the future be recognized in this territory.

The typical subspecies is quite consistent in its characters and range, and forms a well defined unit. This is especially true in the northern part of its range beyond the influence of other subspecies. Occasionally, one of the features of this form may fall at one locality, but the ensemble of characters remain. Whenever it comes in close proximity with another subspecies to the south or west, however, this consistency of characters is lost, and all forms of intergradations between it and the other subspecies can then be noted.

Volucellus proper is very numerous and at times a dominant fish throughout most of its range. It is especially common in the glacial lakes in moderately weedy situations having a silty or mud bottom. As a rule it occurs but seldom in the more strictly terrigenous and exposed portions of these lakes, where its near relative, *Notropis deliciosus stramineus* (Cope), abounds. This condition holds for the Great Lakes themselves where both these species can be found in abundance, especially in the shallower portions.

It is also a common inhabitant within the above-named area in the streams and creeks, living in the quieter pools having a soft bottom of silt or muck, and is not adverse to a moderate amount of submerged aquatic vegetation. Here again it leaves the terrigenous areas with their usually swifter current to *N. d. stramineus*. Towards the southern part of its range *volucellus* proper becomes uncommon or entirely absent in the larger streams and rivers.

2. *Notropis volucellus buchanani* Meek ranges from extreme southwestern Pennsylvania westward to Iowa, south to the Rio Grande and Tennessee. More material farther south from northern Mississippi, Louisiana and Texas will probably show this form to be not uncommon there in the larger streams.

Buchanani does not appear in typical form anywhere in the Great Lakes drainage. But along the Maumee river, and northwestward across Lake Erie to Big Creek, Elgin County, Ontario (Hubbs and Green, 1928: 378), *buchanani* influence is noted, cropping out in isolated places in a most interesting manner. This apparently is a relic from the time when the connection between the Wabash and Maumee rivers still existed.

Since typical examples of *buchanani* throughout the known range show but little variation, this subspecies forms a well defined unit. As pointed out by Hubbs and Green (1928: 378), it is a smaller and much daintier fish than *volucellus* proper; is sharply compressed; has greatly elevated lateral line scales; very large and delicate fins and but few melanophores on the body. The two characters last named suggested the vernacular name "ghost shiner," which has been used by recent authors.

In the northern part of its range, at least, *buchanani* is confined to the lower portions of streams flowing through lowlands, where they have a southern fauna. Here it is to be found living over a silty bottom in a very sluggish to moderate current, and penetrating freely into weed beds when these are present.

3. A third form, confined to the Ohio and upper Mississippi rivers and the lower courses of their larger tributaries, is now described:

Notropis volucellus wickliffi, new subspecies.

Diagnosis.—This form of *Notropis volucellus* differs from *N. v. buchanani* in growing to a much larger size (reaching the total length of 56 mm. from tip of snout to base of caudal); in having a larger eye; longer and heavier head; much deeper caudal peduncle; larger mouth; lower and more rounded fins with less feeble rays; and in the less elevated and less imbricated scales. In these respects it approaches or agrees with the typical subspecies. From *N. v. volucellus* the new form differs in having slightly larger fins, and in the more anterior insertion of the dorsal. It is differentiated from both *volucellus* proper and *buchanani* in having a relatively larger mouth; deeper caudal peduncle; a heavier head; a more turgid body; less elevated lateral line scales, and a more solidly and evenly stippled dark lateral band on the tail region of the body.

Range.—This form is apparently confined to the larger and deeper waters of the Ohio and upper Mississippi rivers and the lower courses of their larger tributaries. It is represented in the Museum of Zoology by specimens from Ohio, West Virginia, Kentucky, Indiana, Missouri (St. Louis) and Wisconsin.

In the spring vast numbers of this form migrate from the Ohio river up the larger tributaries to spawn, retreating later to the main stream. There is no indication of its occurrence anywhere in small streams or lakes. But very few of the record stations are more than fifty miles away from either the Ohio or Mississippi rivers. The significance of this statement is enhanced when it is considered that all of the hundreds of collections made in the course of the Ohio and Wisconsin fish surveys, containing thousands of specimens of *N. volucellus* from all sections and types of habitats in these two states, have been studied in the preparation of this paper.

Holotype.—A breeding male 48 mm. in length from the tip of the snout to base of caudal, collected by M. B. Trautman and R. B. Foster at the mouth of the Miami river at its confluence with the Ohio river in extreme southwestern Miami Township, Hamilton County, Ohio, on May 25, 1931; Cat. No. 92411, Division of Fishes of the Museum of Zoology, University of Michigan.

The body is decidedly terete, more so than in *volucellus* proper and much more than in *buchanani*. The width is contained 1.5 times in the greatest depth (taken just before the dorsal). The depth enters 4 times into the standard length of the body; the head 4 times. The orbit, contained 3 times in the length of the head, is quite conspicuous and bulging. Upper jaw 3.5 in length of head.

The caudal peduncle enters 2.25 times in the length of the head. As in other forms of this species, the dorsal fin has 8 rays; the anal 8 rays; and the pelvics 8 rays each. The height of the depressed dorsal fin is contained 2.25 times in the distance from the origin of that fin to tip of the snout. The origin of this fin is equidistant between the tip of the snout and the base of the caudal. The pelvics do not reach to the origin of the anal fin.

Scales 5½-35-4; 3½ to pelvic; 15 before the dorsal. The highest lateral line scales on the exposed fields are only about 2.5 times as high as long.

The general color is silvery. The dusky lateral streak is well developed and is thickly and uniformly stippled, especially posteriorly. Two small black dots mark each scale in the lateral line, one above the pore and the other below, these becoming quite indistinct towards the tail when they merge into the lateral band. The dark margins of the dorsal scale pockets are more diffuse than in typical *volucellus*.

Pharyngeal teeth 4-4 (many paratypes examined), strongly hooked, and with the grinding surfaces but slightly developed or absent.

The nuptial tubercles correspond well with the description given by Hubbs and Ortenburger (1929: 68) for southern forms of the other two subspecies. They cover the head, and are but weakly enlarged between the eyes. They become obsolescent toward the dorsal fin and are generally absent on the sides of the body, except on the lateral line scales. Here they form a vertical row near the base of each exposed field, and another incipient row near the margin. On the pectoral rays they are in one row basally, and in two, rarely three or four, distally.

Numerous paratypes from Ohio and Wisconsin are deposited in the Museum of Zoology of the University of Michigan and in the Ohio State Museum.

Variations and Comparisons.—This subspecies shows a moderate amount of variation, as is to be expected of any form within such a plastic species. Due to this variability, no single character can be found that is everywhere constant. For the certain identification of material of any subspecies of *volucellus*, it is necessary to study several characters, preferably in several specimens.

The shape of the body averages more terete and is more turgid than in *volucellus* proper, and much more so than in *buchanani*. This effect is heightened by the heavy caudal peduncle and heavy, rather squarish head.

The width is contained in the depth from 1.50 to 1.75* in the present form; 1.65 to 1.95 in *volucellus* proper; and 1.95 to 2.15 in *buchanani*.

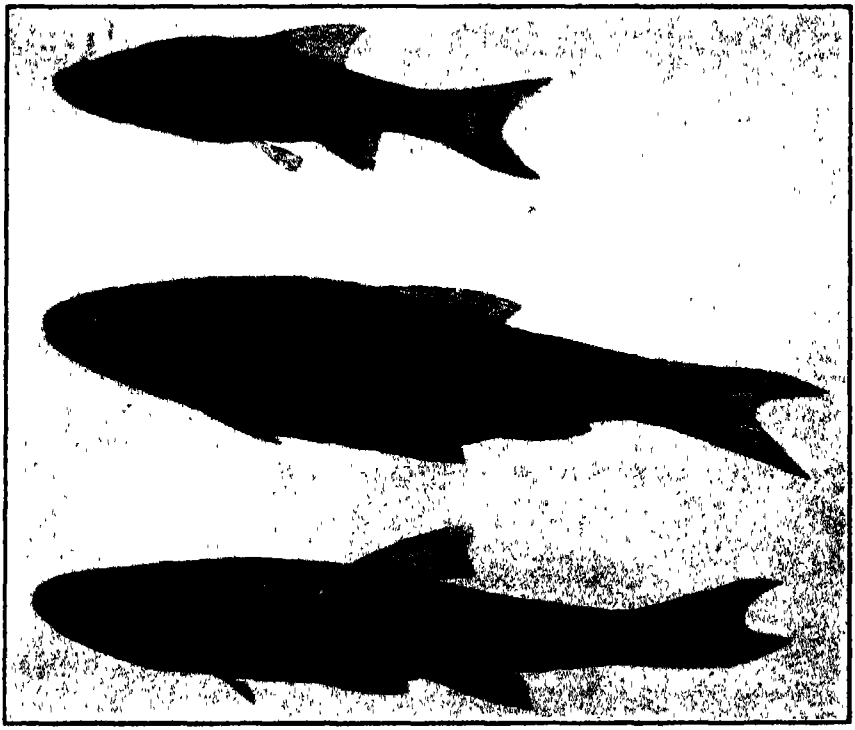

FIG. 1. The three subspecies of *Notropis volucellus*. Upper figure, *N. v. buchanani;* middle figure, *N. v. wickliffi;* lower figure, *N. v. volucellus.*

The depth varies from 3.90 to 4.35 in the standard length in *wickliffi;* 4.6 to 5.0 in typical *volucellus;* and 3.6 to 3.9 in *buchanani*.

The head is contained from 3.9 to 4.1 times in the standard length in the present form, agreeing in this respect with typical *volucellus;* but not with *buchanani,* in which form the head is contained from 3.6 to 3.9 times in the standard length. The whole head is thicker and more heavily built in *wickliffi* than in the other two.

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*The usual and not the extreme variations are indicated.

The orbit of the present form is contained 2.9 to 3.3 times in the head; in *volucellus* proper 2.9 to 4.0 times (averaging 3.0 in some northern lakes and 4.0 in others); and in *buchanani* 3.5 to 4.0 times.

The mouth averages larger than in the other two subspecies. The upper jaw is usually contained from 3.4 to 3.6 times in the length of the head; in *volucellus* this measurement ranges from 3.5 to 4.0; and in *buchanani* from 3.9 to 4.1.

In the present subspecies the depth of the caudal peduncle is contained from 2.2 to 2.4 times in the length of the head; 2.6 to 2.8 in typical *volucellus;* and 2.8 to 3.05 in *buchanani.*

The height of the depressed dorsal is contained slightly more than 2.0 times on the average in the distance from the origin of the dorsal to the tip of the snout; in typical *volucellus* this fin is slightly shorter, usually contained 2.3 to 2.6 times in the predorsal length, while in *buchanani* it is longer, being contained 1.6 to 2.1 times in the same interval. The origin of this fin is directly above or but slightly in front of the insertion of the ventral fins; in *volucellus* proper it is inserted a trifle behind the vertical; from the origin of the ventral; and in *buchanani* this fin is decidedly behind the vertical from the origin of the ventrals.

The rows of scales in the lateral line usually number 34 or 35; in *volucellus* proper there are usually one or two more; in *buchanani* one or two fewer.

The scales along the lateral line are less elevated than usual in the species, as the width of the exposed portion averages only 2.5 times in the height of the most elevated scales; in *volucellus* proper this value is about 3.0; and in *buchanani* about 4.0.

The general coloration is not so intense as in typical *volucellus* except along the posterior portion of the lateral band. It is very much more heavily pigmented than in *buchanani.*

Intergrades between *wickliffi* and *volucellus* proper have been found in collections from Ohio and northern Wisconsin; and intergrades between it and *buchanani* from Ohio. Intergrades between *volucellus* and *buchanani* have also been examined.

The occurrence of these intergrades and the high degree of overlapping in all the varying characters in all the forms, calls for treating them as subspecies rather than as species, as one would certainly treat them if only typical examples of each were at hand. The contrast between extreme examples of these three subspecies is most striking. (See figures).

In as much as *wickliffi* occupies a territory more or less between the centers of the ranges of *volucellus* (subspecies) and *buchanani*, one might be inclined to interpret it as representing intergrades between the two. It does have in fact some intermediate characters such as general paleness, size of the fins and obliquity and terminal position of the mouth. But as evidence of the subspecific distinctness and integrity of the form, it may be pointed out that in other characters it is not intermediate; that in some respects it shows extreme characters (see diagnosis); and that it occupies in abundance and virtually exclusively a very distinct habitat along hundreds of miles of main river course.

Habitat.—*N. v. wickliffi* has been noted in wholly typical form only in the largest rivers (within the range given above), where these have a silty bottom and practically no submerged vegetation. It is not adverse to turbid conditions or a good current. In the Ohio river and the lower courses of its tributaries, in Ohio at least, this form greatly predominates. It is a deep water shiner, straggling in but few numbers into the shallower portions during the day, especially if the water is clear. Toward evening during the summer months *wickliffi*, together with its close associates, *Hybopsis storerianus* (Kirtland), *Notropis blennius* (Girard) and *Notropis atherinoides* Rafinesque, can be seen coming to the surface in great numbers to feed, or jumping from the water when chased or startled. They appear in large schools in the shallower water at night. Due to its abundance it is undoubtedly of economic importance as a forage fish.

It gives me great pleasure to dedicate this form to my loyal friend, Edward L. Wickliff, who has done much in carrying on and furthering ichthyological research in Ohio.

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A QUANTITATIVE NET-PLANKTON SURVEY OF EAST AND WEST RESERVOIRS, NEAR AKRON, OHIO.

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INTRODUCTION.

The Lakes.

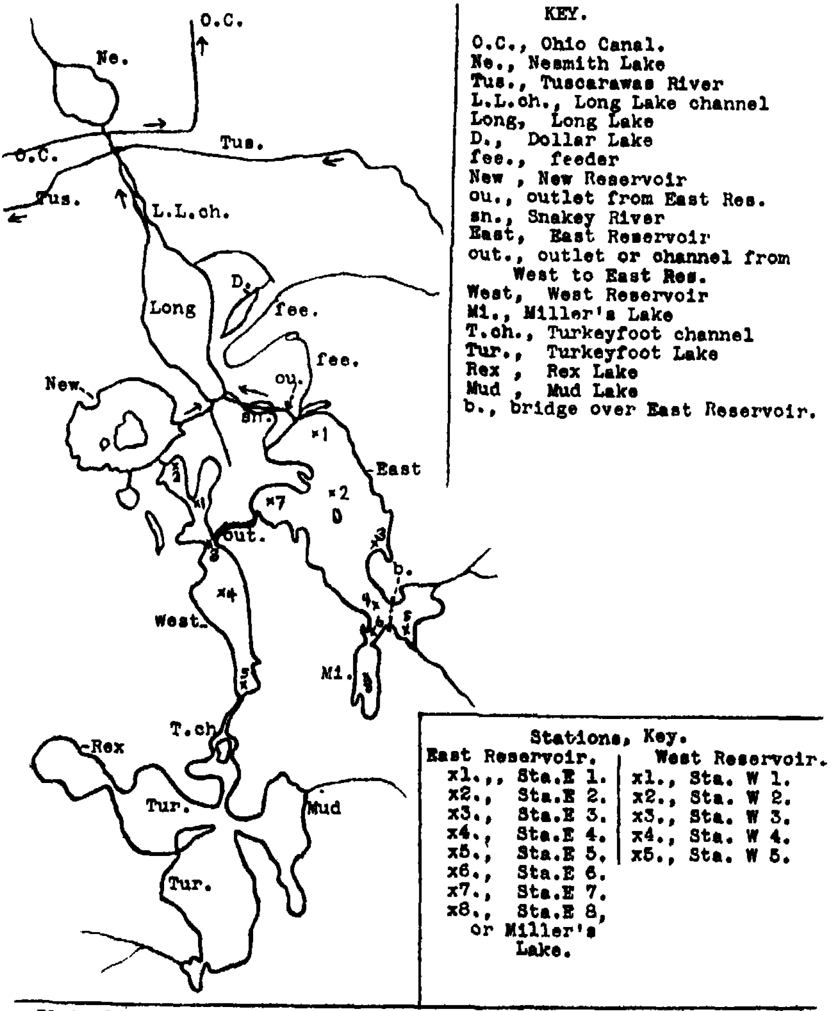
Plankton investigations of some of the Portage Lakes near Akron, Ohio, were started by the writer several years ago, but the only systematic work done thus far is the brief net-plankton survey of East and West Reservoirs reported in this paper.

The Portage Lakes consitute a chain of lakes south of Akron. Several of the lakes are in part relics of glacial times, and some are largely of artificial origin. East and West Reservoirs are of the latter type but are old and have long been in good biological condition.

East and West Reservoirs are connected by a long, bent channel, which though shallow, is navigable by small boats. West Reservoir, smaller and narrower of the two, is also connected by a similar but somewhat broader and deeper channel to Turkeyfoot Lake, which, with its tributary lakes, Rex Lake and Mud Lake, is the largest of the group. These named above are on the same level. North from East Reservoir is Long Lake, at considerably lower level. It receives overflow water from East Reservoir principally through an outlet at the northern tip of East Reservoir, but also through Snakey River, close to it. New Reservoir, somewhat higher than Long Lake, has overflow into the latter. Long Lake has a long channel, quite wide in places, flowing northward, joining the Ohio Canal, to which Nesmith Lake is also joined. The map will show the complicated connections of these waters, which need not be described in detail. Summit Lake, still farther northward on the Ohio canal, and within the city of Akron, is not shown on the accompanying map, which is adapted from a "Detailed Map of the Portage Lakes and Vicinity," made by W. V. Quine, 1927.

Period of Collections.

This report is based on collections entirely from these two reservoirs, made from April to October inclusive, 1929. Collections were also made in 1928, but none earlier than June 30, and unfortunately these were made at different intervals and at different times in the month and especially in the earlier collections, not with the same accuracy and uniformity of



KEY.

O.C., Ohio Canal.
Ne., Nesmith Lake
Tus., Tuscarawas River
L.L.ch., Long Lake channel
Long, Long Lake
D., Dollar Lake
fee., feeder
New , New Reservoir
ou., outlet from East Res.
sn., Snakey River
East, East Reservoir
out., outlet or channel from West to East Res.
West, West Reservoir
Mi., Miller's Lake
T.ch., Turkeyfoot channel
Tur., Turkeyfoot Lake
Rex , Rex Lake
Mud , Mud Lake
b., bridge over East Reservoir.

Stations, Key.

East Reservoir.	West Reservoir.
x1.,, Sta.E 1.	x1., Sta. W 1.
x2., Sta.E 2.	x2., Sta. W 2.
x3., Sta.E 3.	x3., Sta. W 3.
x4., Sta.E 4.	x4., Sta. W 4.
x5., Sta.E 5.	x5., Sta. W 5.
x6., Sta.E 6.	
x7., Sta.E 7.	
x8., Sta.E 8, or Miller's Lake.	

Plate 1. The Portage Lakes, near Akron, Ohio, (Summit Lake omitted), and showing Plankton Stations on East and West Reservoirs.

method prevailing for the 1929 collections. It was therefore entirely inadvisable to use any counts of the 1928 plankton in close comparison with detailed counts of the 1929 catches presented in this paper. There would be no accuracy in any averages that could be made of those two years. Only through absolute uniformity of method through a period of years would averages be very significant. It has been impossible to continue the same detailed work since, though it is planned for some future time to make a similar one year survey of the same lakes for a later comparative report if that is found advisable. The delay in this report is due to the dependence upon vacation time for all of the microscopical observations and tabulations. In the general discussion of this paper some use is made of a certain late summer 1928 collection, made by chance at a very similar time as a 1929 collection, the comparison concerning only very abundant organisms.

Purposes of the Investigation.

The investigation had these purposes: to get idea of the chief plankton organisms of these lakes and their relative abundance, to get idea of the seasonal distribution, which in this case is the variation from late April to late October, and to get data on horizontal distribution as seen in different stations, and also on vertical distribution, as far as possible in such shallow waters.

Limitations of the Investigation.

The survey was entirely of the net-plankton, not of the nanno-plankton or minutest organisms. It is quantitative, as plankton organism enumeration was carried on throughout. Results are given as so many organisms per liter of lake water. The method of "standard area units," (see Whipple, 1927, pp. 124–5), in which size of organisms is taken into account may be significant in sanitary analysis, but does not appeal to one listing organisms for a biological survey. There is here no bulk measurement of so many cubic centimeters of plankton per cubic meter of water, etc., as expressed by Whipple in his discussion of "standard cubic units," (Whipple, 1927). No weight determinations were made of plankton or of organic matter of the plankton, as recently carried out by Birge and Juday (1922), and others. There was no attempt to make estimates of the productivity of the lakes as for instance of so many grams of organic matter per cubic meter of water.

In connection with this biological investigation no chemical analyses of the water were made, and no physical measurements, except that surface water temperatures were taken. No equipment was available for taking temperatures in deeper water.

The two lakes are shallow, and it seems from a considerable number of soundings made at selection of stations, that depths of over 15 or 18 feet in times of high water, must be few. Large areas of the middle of the lakes may not be over 10 feet deep. Undoubtedly both lakes are shallower than Turkeyfoot Lake.

ACKNOWLEDGMENTS.

Thanks are due the Division of Conservation of the Ohio Department of Agriculture, and particularly to Mr. E. L. Wickliff, Chief of the Bureau of Research of that Division for material help in the investigation. The Division purchased the Birge closing, quantitative tow net for the writer, and vials and bottles. Also an outboard motor boat belonging to the conservation warden of the district was at my disposal. The microscopic equipment used and the counting cell belong to the Department of Biology, University of Akron.

I also wish to thank the following for identifications of some plankton organisms: Dr. L. H. Tiffany, for numbers of algæ determinations early in my collections; Dr. Lowell E. Noland, for the identification of the Protozoan Codonella; Mr. Frank J. Myers for identification of rotifers, especially Synchaeta and Anapus, (which he pointed out is now Chromogaster), and in fact for identification to species and variety of all rotifers in some samples sent him. I require only generic names of the commoner forms. He also used the newer genus name Keratella for the older Anuraea, which I venture to retain however, since it will be more readily recognizable by readers. I also wish to thank Prof. Chancey Juday for help in response to many questions on plankton methods I put to him, and likewise Dr. Stillman Wright and Mr. Wilbur Tidd for their replies to questions on their plankton methods.

METHODS AND APPARATUS.

Collecting.

Collections were made with a Birge closing, quantitative, plankton tow net, made by Mr. J. P. Foerst of Wisconsin. The silk bolting cloth was of the very fine mesh, old number 20, new number 25. The collecting method is the old one dating from 1882 (Henson 1887). No other collecting device was used. For this general method see chapters on collecting in Ward and Whipple (1918), and Whipple, (1927).

In figuring the volume of water strained by the net the following results were obtained. The upper net ring diameter being 10 cm., the area of collecting surface, was ($r^2 \times \Pi$), or $5^2 \times 3.1416 = 78.5$ sq. cm. All hauls were made 1M. in length. Hence the water column traversed was a cylinder, 78.5×100 cm. = 7850 c.c. or 78.5 liters.

But any fine mesh tow net strains less water actually than the column traversed, as has been noted by various investigators. "The whole column of water through which the net passes is not strained however, since the straining part of the net offers some resistance to the passage of the water and a certain portion of it is pushed aside and not strained. This makes it necessary to determine the efficiency of the net, or the coefficient, which serves as a factor for calculating the total number of organisms in the column of water." (Birge and Juday, 1922, p. 8). And these investigators point out that in addition variations in the quantity of the plankton causes slight irregularities in the actual water strained and that the aging of the net does likewise due to more and more clogging of the net. Mr. Juday supplied the coefficient of the net, which is 2; that is the number of organisms secured in any catch would have to be multiplied by two. Birge, in an early paper, (1896) discussed the problems of net coefficients.

The speed of hauling the net alters the coefficient slightly. In an earlier report, Juday (1896) pointed out that a net drawn 77 cm. per second strained one-half of the water traversed so that the efficiency was 50% or the amounts of plankton secured would have to be multiplied by two. Under other net conditions this might vary. Through some initial trials the writer secured some such speed and the "feel" of the pull of this sort of haul, which is not very fast and can be carried out, was so impressed that a rather uniform haul could be maintained thereafter.

Hauls of the net were not as difficult as they would be in larger bodies of water where there was more wave action. Only seldom was there enough wave motion to make it difficult to read the exact depth on the calibrated line of the net. Surface records so-called were made by hauling the net one M. horizontally, gauged by a M. marked off at edge of boat, holding the net rim just completely submerged in the water.

The collections were made at 5 stations on West Reservoir, and 8 on East Reservoir. These are designated on the map, (Plate I) and on my records as W1 to W5 and E1 to E8. Of the 8 on East Reservoir, the last or E8 is in a tributary Lake, Miller's Lake. For some purposes in this work this is regarded as a separate lake. Station E1 was out in the middle of the northeast arm of the lake, one of the deeper stations; a 3-4 M. haul could be secured there. E2 was in the center of the largest part of the lake, which was shallower however owing to its proximity to a sandbar, and allowed no deeper haul than 1-2 M. Later some deeper spots were discovered some distance off from this station. E3 was nearer shore in a cove, but allowing also a 1-2 M. haul. E4 was near the center of the channel between the two larger parts of the lake, and quite deep, though not allowing quite for a 3-4 M. haul. E5 was in a shallow area not far from shore in a smaller lagoon-like area of the lake, but this part is not cut off from the larger lake, the apparent cut-off on the map being a bridge. E7 was in the middle of the smaller or northwest arm of the lake; and was deep enough for 3-4 M. haul. E8 was in the center of Miller's Lake, tributary to East Reservoir. It was also deep enough for a 3-4 M. haul. On West Reservoir, W1 was in deep water a short distance from a promontory separating the two northern arms of the lake. A 3-4 M. haul could be made there. W2 was in the upper, middle part of one of these arms, and also deep enough for a 3-4 M. haul. W3 was in the middle of the narrow part of the lake where the channel from East Reservoir meets West. W4 was in the center of the largest part of this lake, but an area not deep enough to yield a 3-4 M. haul. W5 was near the southern end of the lake, in the center near that end near the channel which joins Turkeyfoot Lake.

All stations were distinctly off shore enough to escape littoral conditions. No collections were made where surface vegetation like Lemna or Wolffia occurred. No collections were made where the net would in making the actual measured haul upward, be in any dense bottom vegetation. So few depth samples could be secured because always the depth has to be such as to allow the bucket to be free from bottom mud, or nearly 1 M. more than greatest depth sample actually used. Thus only three stations out of eight on East and two stations out of five on West were deep enough for a 3-4 M. haul. In all the rest no deeper haul than 1-2 M. was secured. In all of the stations there was this 1-2 M., haul except at E5, where only the surface haul was made. Late in summer when the water depth decreased, station E5 was moved out farther into the lake.

Hauls of merely one meter may seem short, but longer ones were not feasible if more than one vertical sample was to be secured from such shallow water. There was hope of recognizing some differentiation in water samples, collected at surface and at depths 1-2 M. and again at 3-4 M. The intervening meters of water were not sampled, or the water samples were made discontinuous in hope of showing any existing differences distinctly.

Collections were made on April 20, May 25, June 21, July 20, Aug. 21, Sept. 21, and Oct. 26.

All collections were made in daylight at approximately same time of day. The collections from all stations requiring a minimum of three and one-half hours, were always made in the same sequence, so that even though there were delays in starting or frequently during the work, the light conditions were not materially different in the different trips, except as seasonal or weather differences brought about, and on all collecting days weather was clear except for the April collection when the sky was overcast and a light drizzle fell part of the time.

The plankton water samples were collected in vials from the bottom of the net bucket. A small, uniform amount of water from a wash bottle was used to help wash organisms into the vial. The samples then varied usually between 10 and 15 or maybe 20 c.c. The exact size of sample at collection is of no significance, provided it is made of uniform size with others by distilled water in subsequent work. About 1-2 c.c. of strong formaldehyde was put into each vial before collecting the lake water into it.

Not all limnoplankton can be secured with the plankton net, as a host of the smallest organisms, the nannoplankton, would escape unless accidentally held in masses with larger organisms. Some organisms observed and even a few counted in this work, may seem to border on this nannoplankton group. But all the smaller organisms included are usually listed as being within net-plankton limits, and the same genera are thus listed for instance by Birge and Juday (1922). These smallest ones listed in this paper occur in such large numbers and with such seasonal variation as is considered normal, that it seems certain that appreciably none were lost through the net or that all were collected in the same proportion as larger organisms.

Microscopy.

The microscopic work was done at intervals, chiefly during summer vacations. Only a part of some 1928 collections were examined, at whatever concentration they were at time of collection, and for most samples counted there was too great a concentration of organisms. In all the work on the extensive 1929 collections, varying small amounts of distilled water were added to the plankton water samples, to make the working plankton sample size a number of c.c. which would be a small decimal or simple fraction of the amount of lake water strained by the net. This would make calculations much simpler later than to take some seemingly simple figures as 10 or 20 c.c. for the working sample. Since the theoretical water column of a net haul was 7850 c.c., a sample size of 7.85 c.c. would have been theoretically good, or on the same basis, a sample size of half that would have immediately given in 1 c.c. examined the number of organisms in a liter of lake water, because the 50% net efficiency would actually collect half the organisms, or organisms of half that actual lake water, and multiplying by 2 would give the actual numbers for the 7850 c.c. But such samples are all too small for practical reasons, such as inability to measure accurately in graduate cylinder, and too great a concentration of organisms. By making concentrate 15.7 c.c. and also in many cases 31.4 c.c. then by a simple multiplication of the number of organisms in 1. c.c. of the concentrate, by 4 or by 8 respectively, gave the number in one liter of lake water. In each case the total concentrate was well stirred in a beaker and 1 c.c. of it pipetted into a Sedgwick-Rafter counting cell, (50 × 20 mm., and 1 mm. deep).

Microscopic examination was done under a Spencer low power binocular, and for more magnification under compound microscope, 16 mm. objective. The binocular was used with its highest magnifying power, × 46, for examining the entire cell contents. The cell was moved across the stage against a ruler held by clips, and then adjusted the correct distance for another crosswise movement, a definite number of times until the entire 20 mm. width was covered. Complete counts of all larger organisms and indeed for types down to the smallest recognizable with this binocular, were made. Many more were counted in the whole cell than first planned, but these whole counts bring more accurate results than the counts of smaller parts with calculations, as is necessary for the smallest organisms. Thus not only Entomostraca and Rotifers were fully counted, but such as the Protozoan Ceratium and even the filaments of the algal colony Anabaena.

The compound microscope was used for distinguishing and counting smaller planktonts, or those of too great an abundance to count in entire cell. A 16 mm. objective and 7.5 ocular were used. Higher magnifications were not needed for this work, nor was time taken for thin mounts of any planktonts. The Whipple ocular micrometer was used in counting. With the above combination of lenses a tube length of 184 mm. was necessary to have the large square of the Whipple micrometer equal 1 sq. mm. on the stage. The organisms in a cube covered by such square were counted completely. Twenty such fields scattered rather regularly over the entire cell (equal to 1000 such small fields) were taken and examined fully. The total of counts in 20 fields for any organisms multiplied by 50 gave the total number in 1 c.c. of the concentrate, or counting cell.

This standard method of counting and then multiplying to get total numbers, may result in errors of rather large size, if the numbers of organisms involved is rather small, though only neglegible errors if the numbers are large. This was verified in many cases on organisms of such size that they could be counted under binocular, as rotifers Ceratium, Anabaena filaments, as well as Cyclops eggs, Nauplius larvæ, etc. The method of counting all individuals was compared with the other method and discrepancies noted. Actual examples will not be detailed here, except to note that in several instances cases of Ceratium and also rotifers Anuraea and Polyarthra, were found to have when 20 fields were counted and multiplication made, far too high a number assigned, proven by the actual counts of same samples under binocular, in such cases where the numbers were of the order of 100 individuals for entire cell, though when the actual numbers were of an order of 1000 or thereabouts, no real discrepancies occurred.

This matter must be obvious to most plankton investigators, but has not been stressed much in reports. To avoid as far as possible considerable errors in numbers, as large a number of plankton kinds as could be recognized under the binocular, were fully counted for the entire cell, involving often very tedious work.

No complete list of plankton has been attempted. Only limnetic plankton identified to genus and of such occurrence that at least a few would be encountered from time to time were considered for the actual plankton counts, though if a very rare form were large and identifiable, record was kept of it. No estimates were made of partly disintegrated forms.

DISCUSSION OF PLANKTON COLLECTIONS.

Plankton Kinds and Limitation of Data in Tabulations.

When all plankton counts were made the 1929 collections data were so tabulated that there were 14 tables, one for each monthly collection and each lake, each containing the data of number of planktonts of every kind regularly counted, per liter of lake water, separately for each station and for surface and two depths. Only a few plankton types of large size but very rarely encountered were omitted. These tables are too bulky for presentation. They would show all the minor variations of stations. But since many of the organisms were not commonly found, there would be many blank spaces for absence of various kinds any one month from some or all stations.

The rarely occurring genera that may be noted briefly here included: the Protozoan Vorticella, occurring in small numbers at one station in three collections, the Cladocera Scapholebris and Camptocercus each occurring at only one station in one collection. Also the Ostracod Cypris was found only twice in very small numbers, a surprising rarity considering their abundance in food of some minnows taken in an earlier year, from the same lakes (Kraatz, 1928, and Cassidy, Dobkin and

Wetzel, 1930). Hydra was found in just one collection at one station June 21, (one specimen in surface sample and 4 at 1-2 M.). This meant only 4 Hydra at most in the entire concentrated sample, or less than one per counting cell sample. Presence of this form in the limnetic zone cannot be accounted for. Rarer rotifers included Anarthra, occurring twice in small numbers, and a few others not then identifiable to genus by the writer. Mr. Myers identified to species all rotifers in a few vials sent him, and indicated them as rare, few, common, or abundant. Those he marked rare are omitted from tables, those marked few, referred to (to genus) below, are also omitted from the shortened tables, and only the common and abundant ones are listed to genus in tables in this paper.

Counts were kept of eggs of rotifers, and Cladocera, and of the genus Cyclops. The eggs, often were numerous, especially of Cyclops and rotifers, were however eliminated from the tabulations. A total of 37 distinct genera remain in these longer tables of plankton kinds.

To present more concisely, and at the same time quite fully all the significant comparative data, 20 of the 37 genera were selected on the basis of being the most representative planktonts of these lakes, and either abundant or common, or if seemingly in small numbers, found rather uniformly in many monthly collections. These tabulated (tables 1–7) on basis of monthly collections, show the differences between the lakes, and retain the surface and depths differences but are averages of the several stations on a lake at any one level. Thus at West Reservoir, 5 stations were averaged, at east Reservoir 7 stations were averaged, but No. E8, which is Miller's Lake, tributary to East, was kept distinct.

The plankton types omitted from the tables 1–7, and which were on the whole not as abundant as any included, occurring as very few here or there or in a few cases abundant in one monthly collection, are here listed: the blue-green algæ Merismopoedia, and Oscillatoria, (really abundant in the May collection, and not noticed otherwise); the green algæ, Westella, Staurastrum, Mougeotia; the flagellates (plant or animal) Euglena, Phacus, Synura, Pandorina, Eudorina, and Mallomonas, (which occurred in small numbers in quite a few collections); the Protozoa Arcella and Epistylis; the rotifers Notholca, and Anapus (now called Chromogaster, as Myers pointed out); and the Cladocera Chydoris and Ceriodaphnia.

Since the seasonal distribution is one of the main objectives, the monthly variations were brought together in close comparison, (tables 8–10), one table devoted to each lake, including a separate one for Miller's Lake, and in each case furthermore the plankton number represents an average of all three levels, surface, 1–2 M. and 3–4 M. This method of presenting the summaries and comparison was chosen rather than graphs, because while graphs are graphic, but only obviously so when arithmetical plot is used, the wide range in numbers for some organisms, as in an extreme case the diatom Asterionella, of hundreds of thousands in one month and then a fluctuation of

TABLE 1.

APRIL 20 COLLECTIONS. COMPARISON BETWEEN LAKES AND OF DEPTHS OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1-2 M.	3-4 M	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.
Coelosphaerium	3								
Microcystis	1								
Anabaena	3								
Aphanizomenon									
Melosira	20,920	20,160	21,800	19,315	15,733	8,200	1,000	1,000	100
Synedra	13,280	10,840	8,660	8,671	4 300	3,200	3,200	1,200	1,200
Asterionella	18,400	19,840	13,000	72,885	54,400	24,800	22,200	9,600	9,600
Fragilaria	1,880	800	1,200	115	171				
Pediastrum	89	17	12	15	15	10			
Dinobryon						2			
Ceratium	5	6	2	1	1		4	4	
Codonella	78	114		850	582	644	76	4	
Polyarthra	744	619	734	916	526	320	368	248	300
Anuraea	2,231	1,937	892	632	437	282	1,040	1,016	
Synchaeta	112	71		33	306	2			
Asplanchna	6	2		1			4		
Nauplius	124	111	290	242	115	70	72	72	108
Cyclops	102	82	106	72	55	62	96	108	304
Daphnia	9	10	14	15	16	12	12	4	16
Bosmina	27	30	16	13	38	8	4	12	
Surf. Tempt.	11° C.			11° C.			11° C.		

from several thousands to even a hundred or less for all other months, would require a peak of relatively enormous height in the graph, or most of the other fluctuations of practically microscopic height. Many of the plankton graphs would be more or less of this sort. Or to show fully the main fluctuation, the minor ones would have to be disregarded. If all 20 organisms were fully graphed, more space would be needed than in these tables, as few could be put on one graph.

TABLE 2.

MAY 25 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1-2 M.	3-4 M	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.
Coelosphaerium	30	57	384	25	24	44		32	
Microcystis	27	34	8		60				
Anabaena	464	968	452	299	246	132	32	8	8
Aphanizomenon									
Melosira	7,040	20,720	800	9,829	15,066	12,600	3,800	4,400	8,000
Synedra	7,520	10,080	200	48,600	46,266	30,400	41,200	27,600	24,400
Asterionella	99,160	209,841	217,400	204,228	460,700	304,400	302,800	396,000	380,000
Fragilaria	960	1,680	1,400	182	400	800	800	1,200	800
Pediastrum	42	50	56	51	105	72	16	56	64
Dinobryon	29,920	38,640	10,804	21,886	21,266	7,200	58,400	46,800	20,000
Ceratium	54	98	40	6	27	16	16	40	64
Codonella	6	30	15	26	85	280		16	
Polyarthra	1,560	1,885	428	268	760	308	12,000	1,840	1,440
Anuraea	3,011	3,775	1,213	896	2,108	776	2,368	3,584	1,984
Synchaeta	5	18	8						
Asplanchna	88	78	12	59	222	96	56	200	104
Nauplius	66	181	76	12	147	36		96	48
Cyclops	14	22	4	3	10		8	8	80
Daphnia	6	38	14	1	18	8		16	64
Bosmina	142	95	4	9	48	24	7	16	16
Surf. Temp.	18 5° C.			18° C.			18° C.		

Of all 20 kinds in these tables, possibly Codonella is least known to readers, to those not versed in Protozoology. It can be misidentified, as first by the writer, as a Difflugia. It is a Ciliate with lorica. Codonella belongs to sub-order Tintinnoidea or Tintinnoinea, of the order Oligotricha, which is itself placed by some writers within order Heterotricha. The group outside of a few fresh-water types is marine and pelagic.

TABLE 3.

JUNE 21 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.
Coelosphaerium	208	53	1,750	69	79	332		24	136
Microcystis	136	123	324	72	16	44			16
Anabaena	16,560	12,000	68,200	19,200	8,933	19,000	504	4,800	1,200
Aphanizomenon	3,680	4,960	3,900	28,971	17,533	10,000	2,900	4,400	2,000
Melosira	400	480	800	1,027	666	1,200		1,200	12,800
Synedra	80	320		57	66				1,200
Asterionella	960	649	2,000	6,114	4,933	10,400		4,400	9,600
Fragilaria	320	565	200	914	800	1,200		400	800
Pediastrum	27	41	64	153	114	95	8	160	224
Dinobryon		80	2,400	269	221	68	800	5,200	12,800
Ceratium	419	1,008	1,136	459	421	72	96	1,096	976
Codonella		16		5	9	16		48	
Polyarthra	177	190	24	429	260	24	24	144	80
Anuraea	147	307	120	273	202	68	160	968	400
Synchaeta				67	32	44	32	32	
Asplanchna				3					
Naupliis	70	128	8	41	41	84	32	160	152
Cyclops	10	27	32	7	4	12	8	40	112
Daphnia	5	6	32	12	25	20		56	72
Bosmina	10	64		17	5	8	8	352	
Surf. Temp.	27° C.			27° C.			27° C.		

Horizontal Distribution.

There is first of all no distinct or uniform difference whatever in fauna and flora of East and West Reservoirs, or East Reservoir and its tributary, Miller's Lake. While there was for some planktonts a difference in numbers of some magnitude, this would be a much greater number of individuals from stations of one lake at one collection and often from the other lake at another collection. The chief instances of fairly well-marked differences in numbers of individuals of the two lakes, and in this case Miller's Lake is often counted in with East Reservoir, were the following. Coelosphaerium was commoner in West Reservoir than in East in May, June, Aug., Sept., and Oct.; Microcystis commoner in West than in East in June, Aug., Sept., Oct.; Anabaena was also more abundant in West than East in all of collections, May to Oct.; but Aphanizomenon was commoner in East Reservoir in June and Aug., but commoner in West in Sept., and Oct. Melosira was found more

TABLE 4.

JULY 20 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.
Coelosphaerium	400	454	600	23	53	60			
Microcystis	6	75	8	289	4	8			
Anabaena	7,120	3,600	5,200	1,775	2,341	3,200	184	320	240
Aphanizomenon	1,440	960	800	1,257	933	200		800	400
Melosira	6,240	4,960	5,800	1,371	1,333	600			
Synedra	1,040	1,040	1,000	10,143	9,466	2,400	400	400	
Asterionella				114					
Fragilaria			200		133				
Pediastrum	69	56	52	20	20		24		8
Dinobryon	960		400						
Ceratium	201	318	428	1,229	682	216	64	72	88
Codonella	2	6	20	1	5	20			40
Polyarthra	245	283	140	576	500	264	88	112	128
Anuraea	356	200	244	259	313	124	80	120	200
Synchaeta	2	10	56	182	177	28	120	88	136
Asplanchna		2							
Nauplius	42	109	76	58	144	120	8	16	112
Cyclops	3	21	60	2	10	8		8	
Daphnia	2		12						
Bosmina	2	3							
Surf. Temp.	24.5° C.			24° C.			24° C.		

abundant in West than in East in April, July, Aug., Sept., and Oct. Synedra was commoner in West than in East in April, Aug., and Oct., but commoner in East May, July, Sept. Asterionella was more abundant in East Reservoir than in West in all months except Oct. Fragilaria was commoner in West than in East, April, and May, but commoner in East in June. Dinobryon showed a greater number by far just in Miller's Lake than in rest of East or West in May, June and Aug., but a greater number in West in July. Codonella showed a greater number in East Reservoir than in West in April, but with few differences otherwise. Polyarthra showed greater

TABLE 5.

AUGUST 21 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.
Coelosphaerium	318	752	104	6			8	24	48
Microcystis	75	85	44						
Anabaena	9,976	6,200	5,700	607	759	992	240	56	
Aphanizomenon	3,200	2,880	5,200	1,886	933	600			
Melosira	6,320	7,600	10,800	1,257	1,600	800	400		
Synedra	1,680	1,920	4,000	1,086	400	400			
Asterionella		80	400			200	400	400	2,000
Fragilaria									
Pediastrum	19	3	32	1	4	4			24
Dinobryon	240						1,600		
Ceratium	14	6	8	1					8
Codonella	5	6	4	6	3	8		8	
Polyarthra	391	326	316	88	155	32	112	144	80
Anuraea	214	313	428	49	90	80	40	144	112
Synchaeta	298	168	96	37	37	12	40	64	64
Asplanchna	19	14	8	5	1				
Nauplius	149	126	80	9	41	28		32	48
Cyclops	8	16	44	5	8	8			
Daphnia									
Bosmina	21	22	24		3	8			
Surf. Temp.	23 2° C.			23° C.					

numbers in Miller's Lake in May, greater in East Reservoir in July, but in West in Aug. Anuraea showed greater numbers in West than in East in April, July, Aug., and Oct., but greater in Miller's Lake than the others in June. Synchaeta occurred in greater numbers in East than in West in April, June, and July,

TABLE 6.

SEPTEMBER 21 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

Names of Organisms	Number of Organisms per Liter of Lake Water								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.
Coelosphaerium	700	360	240	38	27		16	16	
Microcystis	225	189	40	15	3				
Anabaena	8,078	3,936	2,980	982	584		24	8	
Aphanizomenon	1,040	320		343	138				
Melosira	20,400	18,480	15,400	13,143	13,800	8,400	400	400	800
Synedra	1,200	160	200	857	1,000	800			
Asterionella	80	80		857	400	2,800			
Fragilaria									
Pediastrum	27	27	44	13	15				16
Dinobryon				57					
Ceratium	19	10	4	15	9	16			
Codonella	18		12	59	60	160			
Polyarthra	341	122	72	158	168	96	72	80	48
Anuraea	213	101	24	109	93	32	136	144	144
Synchaeta	242	181	48	249	303	24	136	136	126
Asplanchna									
Nauplius	176	32	36	90	75	24	24	40	40
Cyclops	19	19	36	21	28	16	8	8	56
Daphnia	3								8
Bosmina	9			6	3				8
Surf. Temp.	17 5° C.			18° C.			18° C.		

but greater in West in Aug., and Oct. These are probably differences of little significance. For other organisms and other months for the above, there were slighter differences. All can be traced on the tables, as the data for the lakes is kept distinct.

As for differences in numbers of individuals in a series of stations on the same lake, few differences would be expected except where the body of water has various distinct bays or parts, well sheltered or isolated one from another. East Reservoir shows few such areas, and no significant station differences, only countless minor chance variations. West Reservoir does show a number of well marked parts. Nevertheless there were no real differences of import to be noted among the stations. This is in accord with findings in other studies. It was noted for instance by Marsh (1903) that horizontal distribution is very uniform. But one discernible

TABLE 7.

OCTOBER 26 COLLECTIONS. COMPARISONS BETWEEN LAKES AND OF DEPTHS, OF THE PRINCIPAL NET-PLANKTON ORGANISMS.

NAMES OF ORGANISMS	NUMBER OF ORGANISMS PER LITER OF LAKE WATER								
	West Reservoir			East Reservoir			Miller's Lake		
	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.	Surface	1-2 M.	3-4 M.
Coelosphaerium	110	184	120	3	11				
Microcystis...... ..	30	40	48	5	4				
Anabaena	217	371	148	53					
Aphanisomenon	80	266		57					
Melosira	12,560	23,600	15,200	2,743	4,000	2,400	400	800	800
Synedra	1,280	2,266	800	1,086	600	400	400		
Asterionella	4,776	12,666	10,400	114	267		400	1,600	400
Fragilaria									
Pediastrum	23	40	16	7	9			8	16
Dinobryon									
Ceratium		2			1				
Codonella	86	121	76	67	85	50	30	48	48
Polyarthra	205	283	100	131	156	96	64	320	160
Anuraea	235	466	140	108	132	96	32	208	120
Synchaeta	224	283	108	71	176	152	24	8	24
Asplanchna	2			27	36	16	16	24	32
Nauplius	50	74	48	62	71	64	16	72	56
Cyclops	16	18	12	14	15	8		8	16
Daphnia	1								
Bosmina	3	5		7	8			8	
Surf. Temp.	11.5° C.			11.5° C.			11.5° C.		

difference holding for both lakes must be mentioned. Somewhat greater numbers of individuals of very many kinds were noted in northern parts of the lakes, (stations 1 and 7 on East and stations 1 and 2 on West Reservoirs). This seemed to be caused in part by winds, though in East Reservoir an effective cause would seem to be the flow towards the outlet at that northern end of the lake. In both lakes winds were frequently seen to be, as seen also in wave action, towards the north and northeast. The station differences as indicated above, have been merged in the averaging necessary to produce the condensed tables.

TABLE 8.

MONTHLY DISTRIBUTION OF CHIEF NET-PLANKTON ORGANISMS OF WEST RESERVOIR.

NAMES OF ORGANISMS	APRIL 20	MAY 25	JUNE 21	JULY 20	AUG 21	SEPT. 21	OCT. 26
Coelosphaerium		157	670	485	391	433	138
Microcystis		23	528	30	68	151	39
Anabaena		628	32,253	5,307	7.292	4,998	249
Aphanizomenon			4,180	1,067	786	453	346
Melosira	21,293	13,853	560	5,667	8,240	18,093	17,120
Synedra	10,927	7,267	133	1,027	2,533	520	1,782
Asterionella	17.080	175,467	1,403		160	53	9,281
Fragilaria	1,293	1,346	362	67			
Pediastrum	39	49	44	59	18	33	26
Dinobryon		26,455	827	453	80		
Ceratium	4	64	854	315	9	11	1
Codonella	64	17	5	9	5	10	94
Polyarthra	699	1,291	130	223	344	178	196
Anuraea	1,686	2,666	101	433	318	113	280
Synchaeta	61	10		23	185	157	205
Asplanchna	3	59		1	14		1
Nauplius	175	108	69	76	118	81	57
Cyclops	97	13	23	28	23	25	15
Daphnia	11	19	14	5		1	
Bosmina	24	80	25	2	26	3	3

Vertical Distribution.

Due to the shallowness of the water, little data on the vertical distribution of plankton can be secured, or in other words there will be little chance for differences in the small depths available in these lakes. The factor of different light intensities enters here in but a small way, except as turbidity governs that. The waters are of average turbidity. No exact measurements were made. The vertical differences show no uniformity that will allow any definite conclusions. The data can be seen in the tables (1–7) where the numbers for surface and depths are given fully, though averaged for all stations at each level. Naturally wider discrepancies for different depths occurred at some stations, but these were compensated for by data from other stations.

TABLE 9.

MONTHLY DISTRIBUTION OF CHIEF NET-PLANKTON ORGANISMS OF EAST RESERVOIR.

NAMES OF ORGANISMS	APRIL 20	MAY 25	JUNE 21	JULY 20	AUG. 21	SEPT. 21	OCT. 26
Coelosphaerium		31	160	453	2	22	5
Microcystis		20	44	100		6	3
Anabaena		236	15,711	2,439		522	18
Aphanizomenon			18,835	797	1,139	161	19
Melosira	14,416	12,495	964	1,101	1,219	11,781	667
Synedra	5,390	8,422	41	7,334	639	686	133
Asterionella	50,695	323,100	7,149	33	67	1,352	300
Fragilaria	95	461	971	44			
Pediastrum	13	76	131	13	3	9	6
Dinobryon		16,781	186			19	
Ceratium	1	16	317	700		13	
Codonella	693	130	10	9	6	93	42
Polyarthra	587	445	241	447	92	134	181
Anuraea	450	1,260	181	199	73	78	120
Synchaeta	114		45	129	29	193	19
Asplanchna		125	1		2		24
Nauplius	142	65	53	107	26	63	45
Cyclops	68	4	8	7	7	22	3
Daphnia	14	9	19				5
Bosmina	20	27	10		4	3	7

Seasonal Distribution.

The monthly variation or distribution, from April to October, is shown on tables 8–10, on which all depths and stations of a lake are averaged together. Summer conditions are most fully demonstrated, but an idea of spring conditions with spring pulses for certain groups and also of autumnal increases and decreases is presented. No winter records are available. The summer seasonal record for the year 1929 may not be entirely representative, but it appears to the writer as if the only unusual thing was the somewhat abnormally lowered temperature at certain brief periods in both July and August, covering the collecting dates in both these months. That is for some days or a week a lower temperature gradually lowered the water temperature at both these times. The one effect that was probably produced was the holding in check of the blue-green algæ, so that there was no very noticeable water-bloom, as has been observed and verified in small samples in other years (1928 especially) to be caused entirely by a flare-up of the same blue-green algæ shown most abundant in this investiga-

TABLE 10.

MONTHLY DISTRIBUTION OF CHIEF NET-PLANKTON ORGANISMS OF MILLER'S LAKE.

NAMES OF ORGANISMS	APRIL 20	MAY 25	JUNE 21	JULY 20	AUG. 21	SEPT. 21	OCT. 26
Coelosphaerium		11	53		27	11	
Microcystis			5				
Anabaena		5	2,168	248		11	
Aphanizomenon			2,800	400			
Melosira	700	5,400	4,666		133	533	667
Synedra	1,867	31,067	400	267			133
Asterionella	13,800	359,600	4,666		933		800
Fragilaria		933	400				
Pediastrum		45	131	11	8	5	8
Dinobryon		41,733	6,267		533		
Ceratium	3	40	923	75	3	5	
Codonella	27	5	16	13	3		42
Polyarthra	305	5,093	83	109	112	67	181
Anuraea	685	2,045	576	133	99	141	120
Synchaeta			21	115	56	133	19
Asplanchna	1	120					24
Nauplius	84	48	146	45	27	35	48
Cyclops	169	32	51	8		24	6
Daphnia	11	27	43			3	5
Bosmina	5	13	120			3	3

tion. Hence a relatively smaller number of these algæ in July and in August, and maybe September, would be the only difference between this record here presented and conditions in many other years.

The Monthly Distribution of the Plankton Groups.

The Cyanophyceæ (blue-green algæ) were at their maximum abundance in June, with a decrease in July and about the same numbers in August, with a continued decrease thereafter. There were none found in April and few in May.

The genus of greatest abundance is Anabaena, and it stood first in abundance of individuals at all times except in one flare-up of Aphanizomenon in East Reservoir and Miller's Lake in June and a smaller increase in East in August. Aphanizomenon on the whole was second in abundance, but was later in starting in spring. Coelosphaerium and microcystis were also prominent types. Oscillatoria was not found at any other time except in the May collections and then was in surprising numbers in fact several times as abundant as Anabaena at the same time. The numbers in both lakes happened to be of about the same size as those of the diatom Synedra found in West Reservoir this same month.

Cyanophyceæ thrive best in warm weather, as found in all investigations, and here indicated, for the June water temperature, at the day collected, was 27° C. at the surface. Whipple (1927) says that usually August would be the month for the maximum, or even September. And in his graph for Lake Cochituate he shows it even for October, which is due he notes to the great abundance of Aphanizomenon in October, a genus said to be more tolerant to cold. In this work Aphanizomenon has its maximum at the same time as other blue-greens. Lack of a continued maximum or even a greater flare-up to cause more pronounced water bloom, in July and August, (as already explained) was due to some brief periods of cooler weather, so that the surface water temperature at time of the July collection was 24° C. and of the August collection 23° C., and that of the September date dropped to 18° C. It seems as if these findings will show, if anything, that as sometimes claimed, the increases in Cyanophyceæ come quickly after onset of hot weather, and decrease as quickly after onset of cool weather.

The diatoms had their maximum abundance in the May collection, but this outstanding position was due largely to the great flare-up of Asterionella at this time. Melosira and Synedra, the other commonest diatoms, and also Fragilaria had about an equal representation in April and May, at surface water temperatures of 11° C. and 18° C., respectively. There was a great decrease in months subsequent, except that Melosira had less decrease, and was unusual among diatoms present in having again a great late summer increase, in September and October, chiefly in West Reservoir. But slight increases were noted also in Synedra and Asterionella, though that is scarcely consistent enough to be significant. Fragilaria, the least common of the four diatom genera, did not have any prominent increase, but was found in variable way in the lakes in April, May and June, with none whatever noted after July.

The productivity of Asterionella at the time of its maximum in May (collection on May 25) was the outstanding maximum of all planktonts in the lakes. The highest averages (tables 9 and 10), show for Miller's Lake 359,000 and for East Reservoir 323,109 individuals. But the maximum numbers encountered at any one station was 547,600 at E 4 at 1–2 M., followed by 521,200 at E 7, 1–2 M. In these and several other cases of higher than average numbers, they occurred at 1–2 M. depth rather than at surface or deeper, though this was not the case when smaller numbers were involved, nor for other organisms.

There was a distinct spring maximum, as frequently noticed for diatoms. Lack of collections earlier than April 20, made it impossible to say when the spring increase started. There is also here evidence for an autumn flare-up, as is often described for diatoms, but it began in late summer and was not nearly so great as the spring maximum.

Green algæ coming within the range of those taken by the plankton net were very few in kind and abundance. Only Pediastrum was found in fair numbers in most collections, and is in fact notable for its uniformity throughout the time of collections. There was a slight decrease in August, but again a compensating increase in September despite the drop of water temperature.

Dinobryon, a peculiar colonial Protozoan had its maximum in May. None were present in April, and small numbers in June and July, decreasing thereafter, with none present in October.

Ceratium a common dinoflagellate Protozoan, had its greatest abundance in June and July, with the next principal appearance in September. There was not so great a fluctuation nor so great a maximum in this genus as in Dinobryon. Fewest were present in October.

Condonella, already referred to, was prominent only in April, when it had a decided maximum, but this flare-up was only in East Reservoir, for at the same time in West Reservoir it was taken at only one station. There was a decrease in May, but rather uniform small numbers in all collections, with another increase in fall.

The rotifers of the genera Polyarthra and Anuraea, (the latter now named Keratella) were prominent planktonts in these lakes, with Synchaeta next in number, and Asplanchna occurred in somewhat smaller numbers and in fewer collections. Of other rotifers, only Anapus, (now named Chromogaster), was anything but rare, and it occurred in considerable numbers only in July.

Polyarthra and Anuraea were surprisingly similar in their general distribution and numbers throughout, with only very minor fluctuations between them. The greatest abundance of both was in May but with nearly as large a number in April. There was no marked monthly change thereafter. Synchaeta was commonest in August, September and October, and least in May and June, but no great variation was presented. Asplanchna, never very common, occurred in largest numbers in May, with a fair number in October. The distribution was peculiar because there were none whatever in September, and practically none in June and July, but a few in August.

Cyclops was the only Copepod present. Nauplius larvæ were also recorded, and both of these relatively larger-sized organisms were fairly prominent, though never abundant. Nauplius was encountered more than Cyclops, and both were in larger numbers in April than later, and both presented a monthly distribution with small fluctuations back and forth.

The Cladocera were not as common as one might expect. Daphnia, (of at least two species) was the largest common Cladoceran, and it occurred in only a fraction of the number of Cyclops. Daphnia was chiefly confined to the collections of April, May and June. The smaller water flea Bosmina was more common than Daphnia, with its maximum also in April, May and June.

On the whole Entomostraca may not be expected to reach such great maxima, according to Marsh (1903), who stated that in shallow lakes plant maxima are always outstanding, while Entomostraca and other zooplankton attain rather small numbers, but that in deeper lakes the zooplankton would attain much larger maxima than in shallow waters.

SUMMARY.

In summarizing these findings the following points might be briefly mentioned. The blue-green algæ in number of kinds and relative abundance are about as prominent as expected in such lake waters, though with the greatest maxima probably not realized in the summer season in which the work was done. The green algæ however were not so well represented. The diatoms were also in kind and abundance well developed and prominent, with the usual dominant ones in the lead here. Among other unicellulars, the Protozoa Ceratium and Dinobryon were prominent, as they often are in lake fauna, and in addition equally prominent was Codonella. Rotifers were found in good numbers and all the types found were common lake planktonts. Possibly the Entomostraca seem somewhat deficient. This is due largely to the surprising dearth of Ostracoda. Cyclops, and a few kinds of Cladocera were fairly prominent and numerous.

The seasonal variations or distribution of the planktonts, which was one of the main parts of this work, shows quite a normal distribution, with flare-up of main or dominant groups at times that show only minor variations from what is usual in such shallow bodies of water.

It is, of course, realized that there may be great variations in plankton distribution from year to year in the same body of water, as was for instance stressed by Birge (1896), but then again Marsh (1903) pointed out that in shallow waters where plants are predominant and furnish the outstanding maxima, there is less variation than in deeper lakes. There is not likely to be a striking variation in these lakes from year to year, at least not in the kinds of plankton, nor even in the general trend of the flare-up and maxima of the several kinds and general time in which there occur, for all the observations made on some samples of plankton of other years, showed exactly the same plankton genera, and as far as data was available, also showed the same trend in their seasonal development. Only the subnormal late July and August temperatures decreased the size of the potential phytoplankton maxima, as already explained.

This paper records the main plankton types of these lakes, and their distribution in various ways, thus giving some data of the plankton biology that may serve as a beginning of a systematic plankton investigation of these lakes and reservoirs.

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FOSSIL FOOTPRINTS FROM THE PENNSYLVANIAN OF OHIO.

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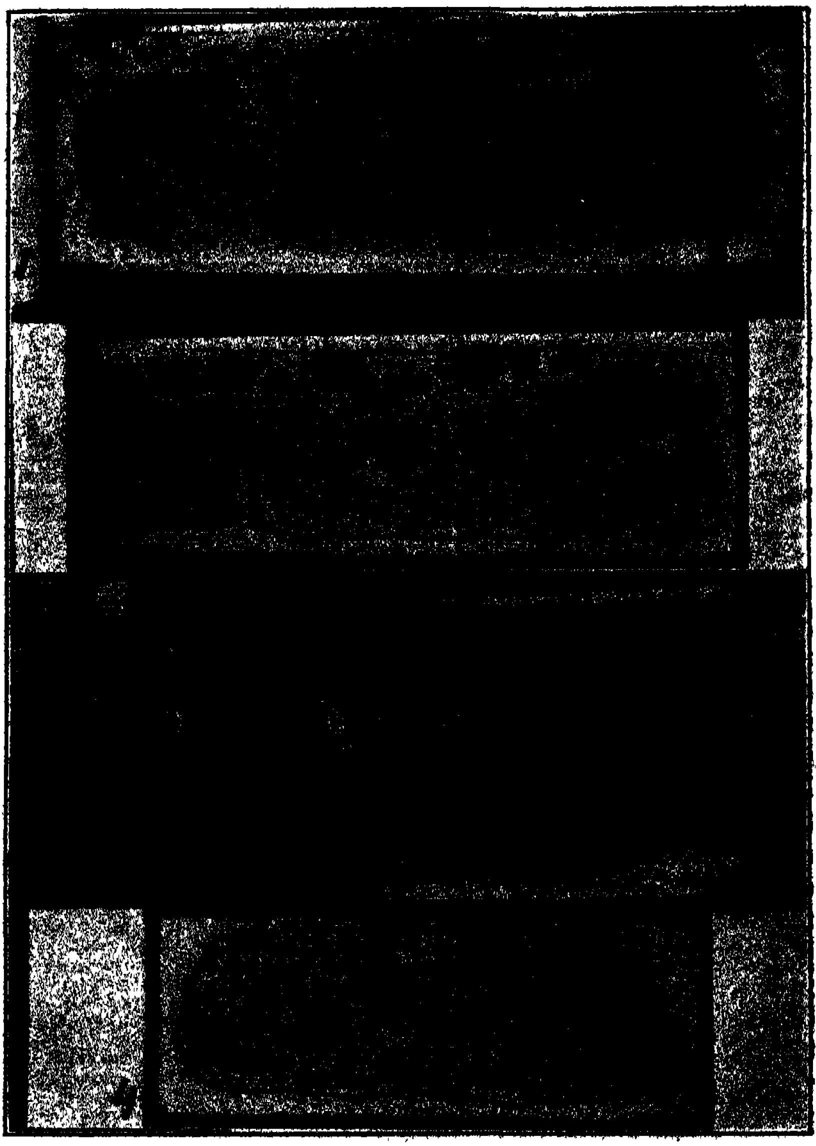
At Senecaville, Guernsey County, Ohio, in the Cleveland Mine of the Cambridge Colleries, there is a remarkable number of fossil footprints, all apparently made by the same type of animal, but unfortunately they are poorly preserved. The mud in which the animal walked must have been rather oozy, for it seems to have partly filled the tracks so that the impression of the foot is not clear. These prints are in the shale above the Upper Freeport or number 7 Coal, of the Conemaugh Formation of the Pennsylvanian System. At a number of places in the roof of the mine the footprints are abundant and being fillings of the impressions stand out in relief, the original impressions having fallen from the roof were removed from the mine.

In a small area of 15 feet by 10 feet 30 prints were counted. At another place 100 prints were counted in a space 15 feet square. In still another place two sets of tracks were found, each set showing 80 prints. In one entry 3 sets of tracks were found which seem to have been made by 3 animals coming from different directions and meeting, then proceeding side by side. Each set contains 24 prints of a hind foot and 24 prints of a front foot making a total of 48 prints made by the left feet of the animal and a like number made by the right feet. As there are 3 sets of such tracks the total number of tracks counted in a space 25 feet by 15 feet was 288. At various places in the mine other groups of prints were found, 100 prints were counted at one place in an area of 15 feet by 10 feet, 160 prints were counted at another place in a space 25 feet by 15 feet, and at still another place in a space 15 feet square 108 prints were counted. Numerous other prints were observed which are not mentioned here. Other observers report large numbers of tracks counted at places in the mine where the shale containing them has since fallen. In most cases these tracks extend diagonally across the entry or almost parallel with it. In many cases not a track in the series is missing.



The tracks are found in two rows corresponding to the right and left feet of the animal. These rows are separated by a distance of about 11 inches. In each row two types of tracks are found which alternate and must represent the front and hind feet of an animal which possessed a plantigrade foot.

The writer knows of no other place in Ohio where tracks are so abundant. In the same shale in which the tracks are found, fossil plants, especially Lepidodendra and Calamites which are preserved as carbon films, are rather numerous in about the same areas as those in which the prints are found. It is quite possible that the amount of vegetable matter in the area has some bearing on the large number of tracks. Possibly the animals congregated here at a feeding ground to eat the apparently abundant vegetation.

Perhaps the best preserved prints from this mine are now in the collection of Muskingum College, New Concord, Ohio. These are two slabs of shale, one 5 feet 5 inches by one foot 8 inches and contains 16 prints or parts of prints. Since the tracks on this slab are fillings of impressions they stand out in relief; however they are not well preserved and are typical of those found in the roof of this mine. Figure 1 shows a photograph of this slab. It will be noted by reference to Figure 2, which is a scale drawing of this slab, that some of the larger prints show 4 toes, the outer one of which is turned outward and back, hook-like. The smaller prints are less well preserved but probably represent the other type of foot.

Figure 3 shows the second slab of the collection, which is one foot 2 inches by 3 feet 9 inches and contains 13 prints or parts of prints. The prints are impressions of the animal's foot and are better preserved than the fillings of the impressions. This slab was found on the mine dump and is the type of impression which falls from the roof of the mine leaving the fillings of the impressions standing out in relief. Note that one type of foot has 4 toes with the outer hook-like digit while the other type has 5 shorter more slender toes.

Figure 4 is a scale drawing of this slab and shows two sets of prints in opposite directions. Those drawn in solid black apparently made by an animal going in the opposite direction to that which made the tracks drawn in outline.

As has already been noted there are two types of tracks, one type has 4 rather long, broad toes, the outer one of which is pointed outward and back, hook-like, while the other type of track has 5 toes which are shorter and more slender. In both types of track the inner edge of the track is deeper than the outer edge, having a depth of about ½ inch. The length of the 4-toed type is about 5½ inches, the toe spread 4½ inches, the width of the sole 2½ inches, length of the sole 3 inches. The inner digit is about 1¾ inches long and points slightly outward. The next digit is 2¼ inches long and is also pointed outward. These digits are about 1¼ inches apart at their ends, and are directed almost straight ahead. The next is about 2½ inches long and points outward, having its end about 2¼ inches from the end of its neighbor. The outer digit, which is about 2 inches long, curves outward and back, hook-like, and is the thickest of the digits. Its end is about 3¼ inches from that of the one just next to it.

The other type of track shows the 5-toed foot which is about 5 inches long. The toe spread is 4¼ inches, width of sole 2½ inches and length of sole 3¼ inches. The digits are all short, about 1¼ inches long, and more slender than those of the previously described type. The outermost digit is one inch from the base of its neighbor and is deeper on the inner side.

The stride of the animal varies from 15 inches in some cases to 17¾ inches in others. The width of the trackway in all cases is about 11 inches. This gives us a ratio of the width of trackway to length of stride of 1 to 1.7.

The description of the tracks on the two slabs pictured here correspond quite well to Ancylopus ortoni, Carman (1), in all ways except size. The general shape of the prints are the same but the stride and the dimensions of the feet are somewhat smaller. It is quite evident, therefore, that they are those of Ancylopus ortoni, Carman. This is, then, a new location for this animal geologically as well as geographically for the type horizon is the shale above the Middle Kittaning Coal, of the Allegheny Formation of the Pennsylvanian System, which is about 100 feet lower than the shale in which the specimens here described were found. All the tracks in the roof of the mine appear to have been made by the same type of animal although they are usually so poorly preserved that one can not be certain. The striking thing about this locality is the great abundance of tracks all apparently made by the same type of animal.

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ADDITIONAL MALLOPHAGA FROM OHIO BIRDS.*

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In a paper published in 1928 Peters listed 94 species of Mallophaga from 114 species of birds taken in Ohio.

The following list includes 45 additional species of Mallophaga from 91 species of Ohio birds. A number of these host records are new as there are, to my knowledge, no published records of any parasite species ever having been taken from some of the host species. In some other instances the record of a parasite species on a host form is new for that host.

Most of the collecting of both birds and parasites was done by the writer during the last four years. Many specimens, however, were collected by Charles F. Walker and Milton B. Trautman whose assistance I gratefully acknowledge.

All the specimens from which this list was compiled are located in the University collection and in my own personal collection.

In this list Harrison's sequence is followed where possible.

LIST OF MALLOPHAGA FROM OHIO BIRDS.

Order MALLOPHAGA Nitzsch.

Suborder AMBLYCERA Kellogg.

Family *Menoponidæ* Mjoberg.

Menopon Nitzsch.

M. maestum Kellogg and Chapman. Towhee, *Pipilo erythrophthalmus erythrophthalmus* (Linn.), Columbus.

Colpocephalum Nitzsch.

C. haliaeti Denny. Osprey, *Pandion haliaetus carolinensis* (Gmel.), Columbus.

C. spinulosum Piaget. Baird sandpiper, *Pisobia bairdi* (Coues), Buckeye Lake.

C. unciferum Kellogg. White pelican, *Pelecanus erythrorhynchus* Gmel. Buckeye Lake.

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*Contribution Number 2, new series, from the Department of Zoology, Capital University, Columbus, Ohio.

Cuculiphilus Uchida

C. fasciatus (Scopoli). Black billed cuckoo, *Coccyzus erythrophthalmus* (Wilson), Buckeye Lake.

Menacanthus Neumann.

M. chrysophaeum (Kellogg). Goldfinch, *Astragalinus tristis tristis* (Linn), Urbana; field sparrow, *Spizella pusilla pusilla* (Wilson), Sugar Grove; song sparrow, *Melospiza melodia melodia* (Wilson), Columbus; meadow lark, *Sturnella magna magna* (Linn.), Columbus; ovenbird, *Seiurus aurocapillus* (Linn.), Buckeye Lake; Connecticut warbler, *Oporornis agilis* (Wilson), Buckeye Lake; northern yellowthroat, *Geothlypis trichas trichas* (Linn.), Columbus.

M. persignatus (Kellogg). Robin, *Planesticus migratorius migratorius* (Linn.), Columbus; bronzed grackle, *Quiscalus quiscula aeneus* Ridgway, Columbus.

Myrsidea Waterston.

M. dissimilis (Kellogg). Tree swallow, *Iridoprocne bicolor* (Vieill), Buckeye Lake; barn swallow, *Hirundo erythrogaster* Boddaert., Columbus.

M. incerta (Kellogg). Olive backed thrush, *Hylocichla ustulata swainsoni* (Tschudi), Columbus; bay breasted warbler, *Dendroica castanea* (Wilson), Columbus; blackburnian warbler, *Dendroica fusca* (Muller), Columbus; hermit thrush, *Hylocichla guttata pallasi* (Cabanis), Columbus.

Machaerilaemus Harrison.

M. laticorpus (Carriker). Bobolink, *Dolichonyx oryzivorus* (Linn.), Columbus; indigo bunting, *Passerina cyanea* (Linn.), Columbus; cowbird, *Molothrus ater ater* (Boddaert), Buckeye Lake.

Actornithophilus Ferris.

A. aegialitidis (Durrant). Black bellied plover, *Squatarola squatarola cynosurae* Thayer and Bangs, Buckeye Lake; ruddy turnstone, *Arenaria interpres morinella* (Linn.), Buckeye Lake; sanderling, *Crocethia alba* (Pallas), Buckeye Lake.

A. tigrus (Kellogg and Mann). Ruddy turnstone, *Arenaria interpres morinella* (Linn.), Buckeye Lake.

A. timidus (Kellogg). Sanderling, *Crocethia alba* (Pallas), Buckeye Lake.

Ferrisia Uchida.

F. laticeps (Kellogg). Snowy Egret, *Egretta candidissima candidissima* (Gmel.), Buckeye Lake.

Trinoton Nitzsch.

T. querquedulae (Linn.). Blue winged teal, *Querquedula discors* (Linn.), Buckeye Lake; green winged teal, *Nettion carolinense* (Gmel.), Buckeye Lake.

Pseudomenopon Mjoberg.

P. pacificum (Kellogg). Yellow rail, *Coturnicops noveboracensis* (Gmel.), Westerville; Virginia rail, *Rallus virginianus* Linn., Columbus.

P. tridens (Nitzsch). Coot, *Fulica americana* Gmelin., Buckeye Lake.

Family *Ricinidæ* Neumann.

Ricinus DeGeer.

R. angulatus (Kellogg). Vesper sparrow, *Pooecetes gramineus gramineus* (Gmel.), Columbus; Lapland longspur, *Calcarius lapponicus lapponicus* (Linn.), Columbus; Savannah sparrow, *Passerculus sandwichensis savanna* (Wilson), Columbus; blue gray gnatcatcher, *Polioptila caerulea caerulea* (Linn.), Columbus; magnolia warbler, *Dendroica magnolia* (Wilson), Sugar Grove; snow bunting, *Plectrophenax nivalis nivalis* (Linn.), Fredericktown.

R. pallens (Kellogg). Prairie warbler, *Dendroica discolor* (Vieillot), Sugar Grove; blackburnian warbler, *Dendroica fusca* (Muller), Columbus; palm warbler, *Dendroica palmarum palmarum* (Gmel.), Columbus; golden crowned kinglet, *Regulus satrapa satrapa* Lichtenstein, Buckeye Lake; Bachman sparrow, *Peucaea aestivalis bachmani* (Aud.), Sugar Grove; tree sparrow, *Spizella monticola monticola* (Gmel.), Columbus; scarlet tanager, *Piranga erythromelas* Vieillott, Sugar Grove; northern yellowthroat, *Geothlypis trichas trichas* (Linn.), Columbus.

Suborder ISCHNOCERA Kellogg.

Family *Philopteridæ* Burmeister.

Goniodes Nitzsch.

G. mammillatus Rudow. Ring necked pheasant, *Phasianus colchicus torquatus* Gmelin, Wellington.

Philopterus Nitzsch.

P. conicus (Denny). Black bellied plover, *Squatarola squatarola cynosurae* Thayer and Bangs, Buckeye Lake; ruddy turnstone, *Arenaria interpres morinella* (Linn.), Buckeye Lake; sanderling, *Crocethia alba* (Pallas), Buckeye Lake.

P. evagans (Kellogg). Red headed woodpecker, *Melanerpes erythrocephalus* (Linn.), Columbus.

P. excisus (Nitzsch). Barn swallow, *Hirundo erythrogaster* Boddaert, Columbus; tree swallow, *Iridoprocne bicolor* (Vieillott), Buckeye Lake.

P. fuscoventralis (Osborn). Olive sided flycatcher, *Nuttallornis borealis* (Swainson), Buckeye Lake.

P. fusiformis (Denny). Least sandpiper, *Pisobia minutilla* (Vieillot), Bono.

P. incisus (Kellogg). Golden crowned kinglet, *Regulus satrapa satrapa* Lichtenstein, Buckeye Lake; tree swallow, *Iridoprocne bicolor* (Vieillot), Buckeye Lake.

P. melanocephalus (Burm.). Parasitic jaeger, *Stercorarius parasiticus* (Linn.), Buckeye Lake.

P. subflavescens (Geoff.). White eyed vireo, *Vireo griseus griseus* (Boddaert), Buckeye Lake; blue jay, *Cyanocitta cristata cristata* (Linn.), Columbus; mockingbird, *Mimus polyglottos polyglottos* (Linn.), Columbus; red winged blackbird, *Agelaius phoeniceus phoeniceus* (Linn.), Columbus; migrant shrike, *Lanius ludovicianus migrans* W. Palmer, Columbus; red start, *Setophaga ruticilla* (Linn.), Sugar Grove; red eyed vireo, *Vireosylvia olivacea* (Linn.), Sugar Grove; purple finch, *Carpodacus purpureus purpureus* (Gmel.), Buckeye Lake; snow bunting, *Plectrophenax nivalis nivalis* (Linn.), Buckeye Lake; hermit thrush, *Hylocichla guttata pallasi* (Cabanis), Buckeye Lake; field sparrow, *Spizella pusilla pusilla* (Wilson), Sugar Grove; slate colored junco, *Junco hyemalis hyemalis* (Linn.), Sugar Grove; indigo bunting, *Passerina cyanea* (Linn.), Columbus; horned lark, *Otocoris alpestris alpestris* (Linn.), Columbus; white crowned sparrow, *Zonotrichia leucophrys leucophrys* (J. R. Foster), Columbus; tree sparrow, *Spizella monticola monticola* (Gmel.), Buckeye Lake; olive backed thrush, *Hylocichla ustulata swainsoni* (Tschudi), Columbus; Philadelphia vireo, *Vireosylvia philadelphica* Cassin, Bono; Kentucky warbler, *Oporornis formosus* (Wilson), Sugar Grove.

Anatoecus Cummings.

A. dentatus (Scopoli). Blue winged teal, *Querquedula discors* (Linn.), Buckeye Lake; gadwall, *Chaulelasmus streperus* (Linn.), Buckeye Lake; wood duck, *Aix sponsa* (Linn.), Buckeye Lake; bufflehead, *Charitonetta albeola* (Linn.), Buckeye Lake.

Degeeriella Neumann.

D. complexiva (Kellogg and Chapman). White rumped sandpiper, *Pisobia fuscicollis* (Vieillot), Buckeye Lake; western sandpiper, *Ereunetes mauri* Cabanis, Buckeye Lake; red backed sandpiper, *Pelidna alpina sakhalina* (Vieillot), Buckeye Lake.

D. fusca (Nitzsch). Sharp shinned hawk, *Accipter velox* (Wilson), Buckeye Lake; red tailed hawk, *Buteo borealis borealis* (Gmel.), Columbus; marsh hawk, *Circus hudsonius* (Linn.), Attica.

D. illustris (Kellogg). Bronzed grackle, *Quiscalus quiscula aeneus* Ridgway, Lancaster; bobolink, *Dolichonyx oryzivorus* (Linn.), Columbus.

D. infecta (Kellogg and Kuwana). Red phalarope, *Phalaropus fulicarius* (Linn.), Buckeye Lake.

D. longa (Kellogg). Tree swallow, *Iridoprocne bicolor* (Vieillot), Buckeye Lake; purple martin, *Progne subis subis* (Linn.), Columbus; rough winged swallow, *Stelgidopteryx serripennis* (Aud.), Buckeye Lake.

D. picturata (Osborn). Meadow lark, *Sturnella magna magna* (Linn.), Columbus.

D. simplex (Kellogg.) Mockingbird, *Mimus polyglottos polyglottos* (Linn.), Buckeye Lake.

D. vulgata (Kellogg). Slate colored junco, *Junco hyemalis hyemalis* (Linn.), Lancaster; white throated sparrow, *Zonotrichia albicollis* (Gmel.), Columbus; Bachman sparrow, *Peucaea aestivalis bachmani* (Aud.), Sugar Grove; cedar waxwing, *Bombycilla cedrorum* Vieillot, Sugar Grove; blue winged warbler, *Vermivora pinus* (Linn.), Sugar Grove; swamp sparrow, *Melospiza georgiana* (Latham), Columbus; English sparrow, *Passer domesticus domesticus* (Linn.), Attica; Bewick's wren, *Thryomanes bewicki bewicki* (Aud.), Columbus.

Rallicola Johnston & Harrison.

R. advena (Kellogg). Coot, *Fulica americana* Gmelin, Buckeye Lake.

R. bisetosa (Piaget). Yellow rail, *Coturnicops noveboracensis* (Gmel.), Westerville.

R. californica (Kellogg and Chapman). Virginia rail, *Rallus virginianus* Linn., Columbus.

Esthiopterum Harrison.

E. botauri (Osborn). Least bittern, *Ixobrychus exilis* (Gmel.), Buckeye Lake.

E. comstocki (Kellogg and Chapman). Yellow rail, *Coturnicops noveboracensis* (Gmel.), Westerville.

E. columbae (Linn.). Mourning dove, *Zenaidura macroura carolinensis* (Linn.), Columbus.

E. crassicorne (Scopoli). Pintail, *Dafila acuta tzitzihoa* (Vieillot), Buckeye Lake; buffiehead, *Charitonetta albeola* (Linn.), Buckeye Lake.

E. forficulatum (Nitzsch). White pelican, *Pelecanus erythrorhynchos* (Gmel.), Buckeye Lake.

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OBITUARIES

JAMES STEWART HINE.*

Professor James Stewart Hine, Curator of the Division of Natural History of the Ohio State Archaeological and Historical Museum, and a recent President of this Academy, died December 22, 1930. His death was due to an acute heart attack and occurred in his home while he, his children and the neighbor children were making preparations for Christmas. Professor Hine had always enjoyed robust health. His taking away was without warning.

Professor Hine was born at Wauseon, Ohio, June 13, 1866, was raised on a farm and worked his way through Ohio State University, where he received the B. S. degree in 1893. From this time to his death his activities were centered on the University Campus, first on the faculty of Ohio State University, and in his later years at the Archaeological Museum. He was Assistant in Horticulture, 1894, and from 1895 to 1899 he was Assistant in Entomology, from 1899 to 1902, Assistant Professor of Zoology and Entomology, and from 1902 to 1925, Associate Professor of Entomology. In 1925 the Ohio State Archaeological Museum decided to develop a Division of Ohio Natural History which could co-operate with the state high schools and Professor Hine, because of his wide knowledge of the state fauna, was asked to organize the division. During 1925–1927 he devoted half his time to teaching and half to the organization of the Division of Natural History. From 1927 till his death, 1930, he devoted full time to the latter position.

Professor Hine was essentially a field and museum man. He was familiar with every region of Ohio and had made many trips farther afield, to the Gulf Coast, 1903; Central America, 1905; California, Arizona and Mexico, 1907; two trips to Alaska, 1917 and 1919, and to Florida and Cuba, 1923. He spent the year 1922–23 studying in the Zoological Museum of the University of Michigan and August cf 1925 in the British

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*Summary of remarks presented at the Oxford meeting of the Ohio Academy of Sciences.

JAMES STEWART HINE

(Courtesy of the Ohio Archaeological Society.)

Museum, besides other shorter trips at times to various American collections.

Besides his interest in insects, Professor Hine was a charter member of the O. S. U. Biological Club, he organized the first Wheaton Club and was President of the second Wheaton Club. He had been President of the Ohio Beekeepers Association and recently (1929) President of the Ohio Academy of Science. In the following articles will be found further details of his scientific work:

McAtee, Waldo. "James Stewart Hine." Auk, Vol. 48, No. 2, pp. 323–325. 1931.

Kennedy, C. H. "Obituary" (James Stewart Hine). Ent. News, Vol. 42, pp. 177–180. 1931.

Galbreath, C. B. "James S. Hine." Museum Echoes (Ohio Arch. Mus.). Vol. 4, No. I, p. 2. Portrait. 1931.

Cockins, E. D. "Publications of the teaching staff." O. S. U. Bull., Vol. 26 (1921), pp. 63–68; Vol. 29 (1925), p. 22.

C. H. KENNEDY.

CHARLES DURY.

The death of Charles Dury on July 20, 1931, in his eighty-fourth year, after a few days illness, has removed from the ranks of American entomology one of its oldest workers. His interests were, however, broader than the branch in which he specialized and by which he is best known among entomologists. He belonged to that old-time group of naturalists—so few in these days of specialization—whose studies embraced the whole field of natural history. In this broader field, his chief interest lay in ornithology; many published papers attest to his careful observations of birds.

Charles Dury was born in Cincinnati, Ohio, November 14, 1847, the son of Francis W. Dury and Louisa M. Gibson. In 1862, Francis Dury settled in the suburb of Avondale (now a part of Cincinnati) and in the immediate vicinity of the original Dury homestead, Charles Dury passed the remainder of his long and active life.

Mr. Dury early acquired a taste for natural history, and in those days, his immediate surroundings offered ample opportunity for the development of his studies. His first active work was in ornithology. To his field observations he added a study of taxidermy, and about 1867, opened a shop for that work, which he carried on some forty years. Many beautifully mounted birds and mammals show his skill in taxidermy, for which he received a number of competitive awards. Early in life he attended the Miami Medical College, but did not carry his studies to completion.

Entomology later increasingly claimed his time and attention, and his collection of insects, particularly of Coleoptera, brought together from all parts of the world, is for North American forms, one of the finest and most complete in this country. This collection is left to his son, Ralph Dury, now Director of the Cincinnati Society of Natural History.

Although he published a number of papers on North American Coleoptera and described many new species, these but poorly represent the extent of his knowledge and the wealth of his observations in his chosen field. An authority on the Coleoptera, it is the regret of his friends and fellow students

CHARLES DURY

(Courtesy of Proc. Junior Society of Natural Sciences.)

that he could not be induced to publish his observations more freely.

An indefatigable collector and observer of nature, Mr. Dury acquired a fund of first-hand knowledge. The benefit of his experience he was always ready to give to others, and through advice and encouragement started many young students along the path to success. The writer of this article will never forget the sympathetic aid given her at the beginning of her entomological studies by this veteran entomologist, nor the opportunity for the exchange of ideas throughout many years.

Through correspondence, association in the field or study in museums, he was well known to the older taxonomic workers in most groups of insects. Entomologists throughout the country, and especially Ohio entomologists, will mourn his passing. Probably his closest entomological friend and his companion of many field trips was Professor J. S. Hine. Both possessed the same untiring energy and enthusiasm that mark the successful field worker.

The versatility of his interests and the long period of his scientific activity brought him in contact with many scientists of an earlier generation and gained for him the friendship of such men as Alfred Russell Wallace, E. D. Cope, Spencer F. Baird, George Horn, John L. LeConte, Robert Ridgway, and Elliot Coues.

Mr. Dury held membership in many scientific societies. The records of the Ohio Academy of Science show that he was a member from 1895 to 1919, Vice-President in 1896, President in 1907, and Trustee of the Research Fund 1907–08. He was a charter and life member of the Cincinnati Society of Natural History, its curator of ornithology and entomology, its Secretary in 1912 and its President from 1914 until his death. The oldest member and a life member of the Cuvier Press Club, he was the custodian of their collection, a generous donor to the collection, and the preparator of nearly all of the specimens. At one time he served on the advisory board of the Audubon Society. He was a former member of the American Association for the Advancement of Science, and at the time of his death, a member of the Brooklyn Entomological Society.

His straightforwardness and integrity of character won for him the respect of all; he was a gracious teacher and a faithful friend.

Surviving him are his widow, Mrs. Pearl Welch Dury; two sons, Ralph and Arthur; a daughter, Mrs. Louise Hippert, and two grandsons. To these, his friends and fellow scientists offer their sympathy in the loss they have sustained.

ANNETTE F. BRAUN.

EDITORIAL NOTE.

In view of the intimate association of Charles Dury and Professor J. S. Hine, it seems fitting that we should present together sketches of their life work in Ohio. Both were born, lived, and worked in Ohio. Both were exceptionally successful as field workers in biology, interested in all phases of life and familiar with native plants and animals, but especially birds and insects. Both contributed extensively to the literature of the Ohio fauna, their papers as listed in the Bibliography cf the Ohio Zoology, numbering fifty-one for Dury and sixty-three for Hine. Both served as President of the Ohio Academy of Science and Professor Hine was, for many years, the business manager of the Ohio Naturalist and Ohio Journal of Science.

H. O.

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